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DINNER TO MAJOR-GENERAL THE HONOURABLE JAMES LINDSAY, M.P.

MANY members of the Royal United Service Institution having expressed a great desire to invite Major-General the Honourable James Lindsay, M.P., to a public dinner previous to his departure for Canada, in order to mark their sense of the eminent services rendered to the Institution by that Officer, a Committee was formed, consisting of the following members, to carry out the above intention:—

Colonel R. A. Shafto Adair, F.R.S.
Colonel T. St. Leger Alcock.
Rear-Admiral Sir George Back, D.C.L.
Rear-Admiral R. Collinson, C.B.
Captain C. R. Egerton, R.N.
Captain E. G. Fishbourne, R.N., C.B., Chairman of the Committee.
Lieutenant-General C. R. Fox.
Rear-Admiral G. Goldsmith, C.B.
Captain J. Grant.
W. F. Higgins, Esq.
W. Stirling Lacon, Esq.
Captain Malton.
Captain E. Packe.
Captain A. P. Ryder, R.N.
Captain Sir Sibbald Scott, Bart.
Commander R. A. E. Scott, R.N.
Captain J. H. Selwyn, R.N.
Lieut.-General P. Spencer Stanhope.
Commander T. E. Symonds, R.N.
Captain A. C. Tupper.
Major L. White.
Colonel P. J. Yorke, F.R.S.

Captain Burgess, Honorary Secretary to the Committee.

The dinner took place at Willis's Rooms, King-street, St. James's, on Saturday, the 18th April, the Right Honourable Sir John Pakington, Bart., G.C.B., M.P., in the chair.

The following members attended the dinner:—

Colonel P. J. Yorke, Chairman of the Council.
W. Stirling Lacon, Esq.
Captain A. C. Tupper.
Major Loraine White.
Colonel J. St. D. North, M.P.
Captain W. D. Malton.
Captain E. Pack.
Commander R. A. E. Scott, R.N.
H. W. Lee Jortin, Esq.
Commodore Sir Fred. Nicholson, Bart., C.B.
Major-General F. W. Hamilton, C.B.
Captain R. Jefferson.
Colonel H. D. O'Halloran.
Colonel Sir Thomas Troubridge, Bart., C.B., Deputy Adjutant-General.
Rear-Admiral Sir George Back, D.C.L.
Major-General C. A. Lewis.
Captain J. Grant, late R.A.
Captain J. S. W. E. Drax, M.P.
Major-General P. Edwards.
Commander T. E. Symonds, R.N.
A. Toulmin, Esq.
Major Balcarres W. D. Ramsay, Deputy-Assistant Quarter-Master-General.

Lieutenant-General J. J. W. Angerstein.
Captain Sir Sibbald Scott, Bart.
Captain J. W. Tarleton, R.N., C.B.
Captain E. J. Ottley.
Lieutenant-General J. R. Craufurd.
Major-General Sir Frederick Abbott, C.B.
Colonel G. F. Paschall.
Captain W. H. Tyler, R.E.
Colonel E. Last.
Lieutenant-Colonel T. St. Leger Alcock.
Captain E. Barnett, R.N.
J. Bird, Esq., M.D., late Physician-General Bombay Army.
Rear-Admiral G. Goldsmith, C.B.
J. Barrow, Esq., F.R.S.
Colonel H. Hume.
Sir Harry Verney, Bart., M.P.
Lieutenant-Colonel F. C. Keppel, Gren. Guards.
Lieutenant-General P. S. Stanhope.
Colonel F. P. Dunne, M.P.
Captain Hon. W. E. S. West, Grenadier Guards.
Captain E. G. Fishbourne, R.N. C.B., Vice-Chairman of the Council.
Captain B. Burgess, Secretary.
Captain M. Petrie, Topographical Staff.
Colonel M. Bruce, Grenadier Guards.
Captain J. H. Selwyn, R.N.
Major E. J. Holworthy, 14th Regiment.
Captain Hon. F. A. Stanley, Grenadier Guards.
W. F. Higgins, Esq.
Lieut.-Colonel J. McNaghten Hogg.
Colonel Hon. R. W. P. Curzon, C.B., Grenadier Guards.
Lieut.-Colonel R. Loyd Lindsay, V.C.
Major-General J. T. Boileau, R.E.
Colonel Sir Charles Russell, Bart., Gren. Guards.
Colonel H. Cartwright, M.P.
Colonel R. H. Beaumont.
Lieutenant-General E. F. Gascoigne.
Colonel C. W. Randolph, Grenadier Guards.
Lieutenant-Colonel F. A. T. Clayton, Grenadier Guards.
Lieutenant-Colonel C. N. North, 60th Royal Rifles.
Colonel the Hon. C. H. Lindsay.
Captain A. T. Blakeley, late R.A.
Rear-Admiral R. Collinson, C.B.
Colonel J. Clarke Kennedy, C.B.

After the cloth had been removed,

The CHAIRMAN said: We are now passing an interval of no very great interest, while we are waiting for that dessert, which I hope we shall all have very soon, and perhaps this may not be a bad opportunity for me to mention a subject not immediately connected with any of the toasts which I shall have the honour of proposing to you. I should be very sorry if the evening were to pass, influential as the assembly now is, if I were not to take some opportunity of stating that it would have been much more numerously attended had it not been for those causes with which all Englishmen are too familiar in the months of March and April. Amongst the members unable to attend are the following:—General Sir John Burgoyne, Bart., G.C.B.; General Sir George Pollock, G.C.B.; Lt.-Gen. the Hon. Sir E. Cust; Admiral Sir George Sartorius; Colonel Shafto Adair; Admiral Tayler, C.B.; Rear-Admiral Horatio Austin, C.B.; General Goodsman; Lt.-Colonel Fletcher; Lt.-Col. Lane Fox; Captain Ryder, R.N.; Captain Cowper Coles, R.N.; Colonel Carleton, and General Peel. Since I entered this house, I have received a letter to the same effect from General Fox. The greater part I believe of these gentlemen assign the same unfortunate cause of severe colds, or some indisposition which has prevented their intention of joining this party to-day.

The CHAIRMAN: Gentlemen, I now rise to propose to you the first toast which is set down for this evening. The toast list before me is by no means a numerous one, but whether it be long or whether it be short, I need not remind you that upon every occasion when Englishmen assemble together for any public festivity, the first toast which they propose is the health of our Sovereign. I think it is hardly necessary for me to remind you, that those who have to preside at public dinners at the present moment, find themselves called upon to propose the health of the Queen under very different circumstances from those which have prevailed during the hitherto long and prosperous reign of Her Majesty. In one respect only are those circumstances not changed—namely, that we now drink, as we have long drank, the health of the Queen of this country, with feelings rather of personal affection than of abstract loyalty. But, gentlemen, we cannot fail to bear in mind, that within little more than the short period of a single year, two of the most remarkable events of Her Ma-

jesty's life have occurred; one the death of her admirable husband, the other the marriage of her eldest son. It is hardly possible for the mind to conceive two occasions more opposed in their nature, but in one respect they have been similar, viz., that they have both of them called forth the sympathy and the good feeling of the people. The death of the Prince inspired a grief widely spread over the whole of the country, and touching the happiness of every home. I doubt whether an event ever occurred in this country, which excited such deep feelings of universal grief—grief inspired by sympathy for the living widow, no less than by admiration for the character of the departed man. The grief was deep, the grief was universal, and why? Because the royal family were universally beloved. No less universal has been the joy, which I am happy to say within the short period of a year, has relieved that grief, and I doubt whether any Englishman can call to mind a more remarkable scene than that which attended the entrance of the Princess Alexandra into London on the day when she made her public entry into this country, accompanied by the bridegroom of the day after. It was a remarkable occasion, and there has not been a town, there has not been a county, there has not been a remote village in England, in which feelings of loyalty and joy have not been felt; joy, proportioned in its intensity to the relief which it afforded from the grief which had been previously felt. Gentlemen, I say that these are memorable occasions, to which I should be wanting in my duty in this chair if I had failed to refer. May both of them, one as much as the other, tend to prove the one gratifying fact, that the Sovereign of this country has excited amongst her subjects a degree of loyalty, devotion, and affection never exceeded since England was a kingdom, and I am sure that you will now, as Englishmen upon all occasions for a long period have never failed to do, join me in drinking, with the deepest feelings of affection, the health of Her Majesty the Queen.

The toast having been duly honoured,

The CHAIRMAN said: Gentlemen, I hardly need say that the next toast on my list is the health of the Prince and the Princess of Wales. It is the first time I have ever had the honour of proposing this toast in that shape, and it must certainly be one of the first occasions upon which that toast has been proposed at any public dinner in this country, and is one on which I need not dwell. It speaks for itself. The Princess of Wales has been welcomed in this country with an enthusiasm which never was exceeded, and which must be most gratifying to Her Royal Highness, and must have proved to her how willing the people of England are to welcome her here as one of the Royal Family of this country. And we cannot say more for the Prince and the Princess of Wales than in drinking their healths, to express our ardent hopes that in their future lives they may follow the example and emulate the virtues of their Royal Parents.

After the toast had been drunk,

The CHAIRMAN said: Gentlemen, I have long appreciated the merits of the two great services of the army and navy, but since I entered this room, I have been peculiarly struck by their modesty. The next toast, which upon any other public occasion it would be my duty to propose, would be the health of those two services, but since I entered this building, I was consulted, being the Chairman of the day, upon the subject, and I said "Of course! always drink the Army and Navy." The answer immediately was, "How can we drink our own healths? we are all either army or navy, and, therefore, we cannot do it." It came practically to this, that I am the only man here who is not in the army or navy. Some people tell me that I am both, and it would be an extremely indecorous proceeding for me to drink my own health. Under these circumstances I hold I am exonerated, which under no other circumstances could I possibly be, for not proposing "the Army and Navy." But, gentlemen, as I am not going to propose the health of "the Army and Navy," it becomes my duty now to proceed to that which is called "the toast of the evening" (cheers), and after the manner in which you have received this preliminary announcement, I am sure I need not ask you to join me in filling a bumper to the health of General Lindsay. Before I proceed further in introducing to your notice that toast, I hope you will allow me to express my own sincere opinion, that you have been; if I may so with the utmost courtesy, that you have not been very judicious in your selection of Chairman; because this dinner is given to General Lindsay by the

members of a body with which I have very little, if any connection, and with regard to the merits of whose proceedings I am really not entitled by experience or personal knowledge to speak, and it is on your behalf, as members of that Institution, that I am now to propose to you the health of General Lindsay. I think I understand my duty, at least thus far, that it is your wish, that speaking in your name and on your behalf, I should tell General Lindsay that you will not permit him to proceed on his honourable mission to a distant land, without receiving a parting assurance of your respect and good-will. It might, perhaps, be natural in my position, and speaking as I thus am called upon to do on behalf of this Institution, for me to dwell for a moment on what are the objects and what is the nature of this Institution. But, gentlemen, I cannot fail to recollect, that only a year has passed away since the objects and the advantages of the Royal United Service Institution were expressed and described in the most clear and eloquent manner by that able and most accomplished man, whom I am sorry to say we have just lost—Sir George Lewis. I could add nothing if this were the moment to attempt to do so—I could add nothing to the clear description of the advantages of this Institution which Sir George Cornewall Lewis on that occasion gave, and, therefore, I will briefly sum up my own view of the advantages of this Institution, by saying that its main objects are to promote those arts and those sciences, and that literature, which are most immediately connected with the great Naval and Military services of this country. Gentlemen, it is hardly possible, I think, at the present moment to imagine objects of greater national importance. Scarcely a day passes without adding something to the scientific discoveries which it is essential for those great services to understand, and, therefore, most valuable must be the aid of any Association which acts as a medium through which the members of those great services are enabled to make themselves familiar with those important scientific discoveries, as from day to day they are made. Well, such as this Institution is, what has been the connection of General Lindsay with it? Feeling, gentlemen, that I was called upon by you, however unworthily, to take the chair to-day, I made it my duty to make some enquiries as to what the history of the Institution has been, and what the connection of my honourable and gallant friend with it has been, and I find these remarkable facts: The very first beginning of this Institution dates from the year 1831; I find that my honourable and gallant friend's connection with it is exactly of 20 years' standing. He joined it, unless I am misinformed, in the year 1843. At that time he was Captain and Adjutant in the Guards. Perhaps I may pause for a moment to say, why was he Adjutant in the Guards? Any man may be a Captain in the Guards, but I speak as a civilian, under correction, if I express my belief that no man can ever be an adjutant in the Guards, unless he is a very sharp and able officer. Time passed away, and in 1850 my honourable and gallant friend became a member of the Council of this Institution, and I find that after a very brief period, I believe for one year, in 1851, he was the object of a vote of thanks for the services which in that brief period, he had rendered. In the year 1855 he was appointed Chairman of the Council, and you will remember I am not familiar with the details of this Institution, and it may be in the position in which I now stand, I may be disposed to overrate the services of my honourable and gallant friend, but I am struck by at least the remarkable coincidence that from the year 1855, when he became the Chairman of the Council, an era of prosperity appears to have dawned upon the Institution. A year or two afterwards, in 1858, the Institution ceased to be what it had previously been, rather a general than a professional museum, and it commenced that career of being a museum and an Institution especially connected with the military services. I find your funded property rose from a minimum, and certainly not a very large minimum for funded property, of 200*l.* in 1853, up to above 3,000*l.* in 1862. In 1857, your Journal commenced—a Journal which is now referred to with pleasure and with advantage by professional men all over the world. This career of success has opened, and these improvements have been made since my honourable and gallant friend has exercised, either as Vice-President, Chairman, or Vice-Chairman of your Council, a constant, vigilant and careful superintendence over your affairs. I find that in the Army Estimates for the present year 400*l.* is voted to promote the objects of this Institution. I am also informed, that although the Admiralty has rather lagged behind the Army—I am very sorry for it—still, I understand, they

are going to mend their ways, and the day is not distant, when they will put a little something into their estimates, which shall contribute to the prosperity and the continued efficiency of this Institution. I find, gentlemen, lastly, that negotiations are going on between the various departments of the Government, with a view to the renewal of the lease of the house which you occupy, and, I believe that this is the last of the many services which my honourable and gallant friend has rendered. You are the members of this Institution, you are more familiar with these facts than I can presume to be, but we public men are to watch the signs of the times, and one of the signs of the present moment is, that I do not believe you would receive these remarks in the cordial manner you have done, unless I was justified in that inference, which, as a mere matter of common sense, I have made. I have found through life, that whenever things happen in this way together, they have relation one to the other, and I am unavoidably led to the conclusion, that you would not have met here to-day—that you would not have received these remarks as you have done—unless you shared in the belief which I entertain, that these progressive advances of this Institution, and these increases in its prosperity, and its efficiency, are to be in no small degree attributed to the zeal, the energy, and ability of our honourable and gallant friend.

Well, gentlemen, so much for the Royal United Service Institution, but you have done me the honour of asking me to take the chair to-day, and therefore I think you will not consider me travelling beyond my duty, if I venture to throw in, in making these observations, some little personal feeling of my own. It is with great pleasure that I thank you for enabling me to join in a tribute to a gentleman for whom I entertain so much regard and such sincere esteem. He has been long distinguished as an officer of the Guards, and I am sure it must be very gratifying to him as a professional man, so very soon after he has attained the high rank of a General Officer, to be sent out to a distant province of England, to command that particular branch of the service with which he has been connected. On his account, therefore, I rejoice in the fact, but self will intrude upon these occasions, and on my own account, I am very sorry for it. I am very sorry on selfish grounds to lose my honourable and gallant friend. The years are not few during which we have sat together in the House of Commons. This, I am quite aware, is not an occasion upon which I should be justified in making any reference to the particular merits or the particular demerits of our party distinctions. I have no such intention, but whatever may be the merits or whatever may be the demerits of Conservative policy, it does so happen that General Lindsay and I have always taken the same view of those merits or those demerits. We have always and repeatedly been side by side in the same lobby. But my connection with General Lindsay, and I am speaking now not of private friendship, but of public connection, has not been limited to our identity of opinion upon public matters in the House of Commons. It has so happened that in that Royal Commission which was called into existence by the noble generosity of the British public, both at home and in the colonies, with a view to relieve the sufferings and the distress which were sure to follow upon a great European war—I allude to the war with Russia—it does so happen General Lindsay and myself were both appointed members of that Royal Commission. But it is not only that we were members of the Royal Commission, we have both been members of the Executive Committee connected with that Royal Commission, and in the discharge of our duties in that Executive Committee, occasions have arisen in which good judgment and some firmness were very necessary, and I am only stating the most strict truth when I say, that in discharging my own duties it has always been a matter of the greatest satisfaction and pleasure to me to find that I agreed upon the various points which have arisen with General Lindsay, because I have always had the highest opinion of his good judgment and his good feeling. Gentlemen, on these grounds I have felt it unavoidable that I should add my own mite to that enthusiasm which has brought you here together, and if I could think it at all possible that either the words uttered by my feeble voice or those cheers with which I know you will follow what I am saying, could by any chance reach the ears of Lady Sarah Lindsay, I should be very glad that she might hear the cordiality with which we wish her husband God speed upon the mission upon which he is going. I should be glad if she could hear how cordially we express our wishes, I will not say that he might main-

tain there in a distant land the same reputation for high honour and ability which he has maintained at home, because that is a matter of course, of that there can be no doubt, but our earnest wishes that he may there enjoy health and prosperity and just honour, and that when the due time shall pass, he may return to this country to resume a career of honour and distinction.

The toast was drunk with all honours.

General LINDSAY: Sir John Pakington and Gentlemen, it is indeed a difficult task for me adequately to express to you the high appreciation which I entertain of the great compliment which you have paid to me by inviting me here this evening. I can assure you it is a compliment, which even if I had words to describe, I hardly think that the words would fully describe the feelings which I entertain in thanking you for the honour you have done me. It is not that I stand here the representative of any successful contest, of any party success, or anything of that description, but it is a compliment deliberately paid to me by a body of gentlemen, who are either serving in the army and navy or else who have served in those services or the services which are accessory to them; and therefore it is, I must be allowed to say, for I feel it to be so, the most distinguished compliment which an officer can receive at the hands of his countrymen. One appreciates it the more, because it does come from those who have been one's brother officers, or many of whom I may still call my brother officers. To you, Sir John Pakington, for the kind manner in which you have introduced this toast to the gentlemen around us, I cannot sufficiently express my thanks. You have been kind enough to detail at some considerable length the services which in connection with others, I have been able to render to an Institution, which I believe is necessary as well as an assistance to the great services of the country—an Institution which already has given great services to the profession of arms, and which I believe in the future, is calculated to become still more efficient. But, gentlemen, in acknowledging the high honour you have done me, I cannot forget for one moment, that if I have been able to render any service to this Institution, from your favour in having elected me to be a leader amongst you, I must be allowed to say, I have been most ably seconded by the rank and file of the Council over whom I presided either as chairman or vice-chairman. I may say, that in either of those positions, constituted as the Institution has been, either Captain Fishbourne or myself have found ourselves somewhat in the position (comparing small things with great things) of a prime minister. For instance, we have our Chancellor of the Exchequer, a gallant officer, Major White. We have a foreign department under the able leadership of Captain Tupper, many foreign governments having presented to us arms, accoutrements, and various other articles of military equipment of their different countries. We have also a colonial department, receiving from many officers serving in the colonies valuable information with regard to the different countries in which they serve, which is also presided over by an able member of the Institution. We have a naval department, with which the names of Captain Fishbourne and Admiral Collinson are most ably connected. We have a war department, with the names of General Hamilton, Captain Tyler, and many others. We have a topographical department, presided over by Colonel Alcock. We have gentlemen serving on the general committee, among whom the name of Mr. Lacon may stand almost foremost, and last but not least, one of the oldest members of this Institution presiding over one of its most important parts—the library, I refer to my gallant friend Colonel Yorke. I think I have mentioned now sufficient to shew—not all, it is true, there are many who have most ably seconded those who have presided over the destinies of the Institution—but enough to serve to show the way in which the Chairman and Vice-Chairman of the Council have been served by the members of the Council in general.

The Institution, as has been told you by Sir John Pakington, commenced in 1831. Its fortunes certainly fell in course of time, but I think it is only right for me to say that the Institution and the rules upon which it was guided, were brought into existence by the old soldiers of the Peninsular war, by the old sailors of the great war with France, who formed the first presidency and council of the Institution, and who foresaw the value that the Institution might be if it was fairly carried out to its legitimate use. And it is most remarkable that the prospectus put forth when the Institution was founded, is almost identical in words with that which now is in the

leading law of the Institution, showing that its promoters looked to carrying out in course of time the very thing which, in 1863, I may say, we are here met to celebrate. The Institution undoubtedly fell from its high estate—it had bad fortune. It began with enthusiasm, and for some time it was vigorously supported by both the army and navy, but we all know that enthusiasm is evanescent, and unless it is fed, it dies. It required in the course of time, that that enthusiasm should be sustained by something practical. Now why was not something practical earlier introduced? Simply and solely because its leaders had not the power of doing so. They in vain tried to get premises large enough, they had a large accumulation of capital, they seized the first opportunity that presented, of purchasing the house where we at present are, which is in a neighbourhood in which it is essentially requisite that we should remain. To have gone elsewhere would have been almost ruin to the Institution, therefore they stayed where they were. They waited till they got the opportunity, and then they purchased the house. No sooner had they done so, than they proceeded to adapt it to their purpose, and in the course of time they built that theatre which has been of so much use to us for the last 13 years. But, gentlemen, the effect of all these purchases was to reduce the capital of the Institution, and by reducing the capital, reducing a considerable portion of the income. But by the time these proceedings had been carried out, that enthusiasm had departed, and the consequence of that was, that the Institution began to fall into decay. You have given me the credit of having revived its fortunes; when we found it in this position, we turned our minds to the mode in which the Institution might be rescued from its former position; and it naturally occurred to us as it would have occurred to anybody else placed in that position, that we must make an entire revolution in the whole system, we had to recollect that the age in which we live is essentially a practical age, and that, if the Institution was to survive, it was necessary that we should bring members to us by giving them something in return for the money which they subscribed; in fact, that it was necessary to make it generally useful to the members, practically efficient to the Services in general, and thus carry out those original views propounded in 1831, which, I think at the present time we may safely say we have been successful in doing. The first person that we consulted on this matter (knowing his ability in conducting scientific establishments, and knowing the attention that he had paid to those subjects), was the illustrious Prince Consort, whose premature death we all so much lament. He was consulted upon the best mode of carrying out the improvements which have been effected. And, here I may be allowed to say, having mentioned his name, that to him we owe the production of the model of the Crimea, which is now placed in the Institution. He was anxious that there should be a record placed there of that remarkable campaign, and of the allied attack upon Sebastopol, which has been so ably carried out by my honourable and gallant friend, General Hamilton,—that model is a remarkable instance of his ability. Having consulted the Prince upon the mode in which we should carry out the improvement of the Institution, we at once set to work, and I can assure those who now listen to me, that we had to encounter a very laborious, I may say, a very dirty business, in ransacking and clearing out from the different cellars and corners of that Institution, the quantity of things which had been presented by gentlemen during a long course of time, and which were really of no use to the Institution; we found the quantity so great, that we at once decided there was but one thing to be done, viz., to make the Institution essentially a fresh one, to discard from the Museum all that was not useful for the army and navy in their several professions, and to supply the place of what we had discarded with models of inventions and models of fortifications, and other objects of a professional character, and which might be useful to the services. That was done, and you have been kind enough to give me credit for that proceeding. I acknowledge the good effects of the course taken, but in acknowledging it, I must say, that I was assisted and cordially supported by other members of the Institution, without whom it would have been impossible for me to have carried it out. The next course taken was to obtain from Government some acknowledgment of the value of the Institution. We owe that to Lord Dalhousie. It was he, who, seeing the merits of the Institution, proposed to the Government that there should be £400 a-year granted to it, and from that moment we date our rise; from that

moment the Institution has been successful, so far successful, that officers in all parts of the world have acknowledged its merits; officers in all parts of the world have joined the Institution, simply and solely because we afforded practical information, which they otherwise could not obtain. The Chairman has alluded to the lease of the Institution. It is absolutely necessary to my mind that the Institution should keep its present site. The reasons are evident. It is in the neighbourhood of the Horse Guards, of the Admiralty, and of Parliament, and in a great thoroughfare. It is convenient to Pall Mall and St. James's, and consequently it is in the best and most central position in which it could be placed. The Government has been applied to on the subject, but as long as arrangements with regard to the Thames Embankment are not completed, there will be no chance of our obtaining a lengthened renewal; at the same time I have every reason to believe there is every disposition to give us a renewal of the present site.

I now have to state what my own view is of the functions of the Institution. I must be allowed to say I have rather a comprehensive view of what that Institution is calculated to do in the way of promoting the progress of military science. In the first place I cannot but suppose, that considering we have had the chair occupied at the annual meetings of that Institution, by some of the most distinguished men of the day, the Duke of Cambridge, the Duke of Somerset, Sir John Pakington, the late Sir George Cornewall Lewis, and the late Lord Herbert,—all of whom in their several speeches, were united in their opinion of the great value that the discussions which take place within those walls have been to the services in general, and to the progress of naval and military science,—I think I am warranted in saying, with the evidence given by men taking so distinguished a part in public affairs, that the Institution holds an important position with reference to the Government. It is evident to me that the Government of the country must benefit by the scientific questions of the day receiving discussion within those walls before they are finally adopted; that principle was broadly laid down by the Duke of Somerset and by Sir George Lewis. We have beheld of late years a great contest going on with regard to guns; I need not mention the name of Sir William Armstrong to bring that topic to your mind, and when I mention his name, I mention it for no other purpose than this, merely that he has been the prominent man in the country with regard to the progress of gunnery science, and, therefore, in mentioning his name, I merely do so as the representative of a principle. It has been more of a naval question than a military question, and during the last two or three years, the system of gunnery has been most ably discussed in the Lecture Theatre of the Institution. Many Members have taken an active part in these discussions. Captain Fishbourne, Admiral Halsted, Commander Scott, and others, have lectured there, and given the service the benefit of their information. It is my belief, without venturing for one moment to reflect upon anybody, that by an earlier discussion of these subjects, there can be little doubt, a large sum of the public money might have been saved. I believe there have been experiments on experiments tried, which might possibly have been saved, had the government had the advantage of the discussions which took place in the Institution. In this country there is one thing perfectly clear, you do not obtain secrecy. In other countries you have it to a large extent. For instance, you may say the Emperor Napoleon takes his own line, he is his own minister, and until lately he was his own Chancellor of the Exchequer, and, therefore, he pursued that course which he thought best and most efficient for the service which he wished to promote. Far be it from me to say, that those in the different departments of this country have not the same wish; but how often is it, and I think my right honourable friend on my left will back me up in saying so, how often is it that the Government of this country are drawn on by a question being taken up for them, and being obliged to follow suit even against their opinion, even in the House of Commons, when very likely if those questions had been ably discussed by officers practically acquainted with their merits, there might have been a pause before adopting a system which might afterwards be regretted. Therefore it is, I am inclined to say, that the discussion of such questions in that Institution is of advantage to the Government and of advantage to the public, and I must also add, a very great advantage to the Members of the Institution. There are members of that Institution who owe to their own ability, as shown in that Lecture Theatre, the advantages which they now enjoy, of having their inventions

taken up by the country. I may safely, I think, allude to Captain Coles, whether his invention be adopted or not, still he has the merit of having brought forward an improvement, an invention at least, of very great merit, which is being now tried in England with some considerable advantage to the service, and which has done him the highest honour. He gives the Institution, at any rate, the credit of having been the first to give him the opportunity of having his invention brought forward and acknowledged. Captain Selwyn is another who is now engaged in carrying out an improved system of submarine telegraphy, which may be in the end of enormous advantage to the commerce and trade of this country, and also in a public point of view. I say that these things do show that the Institution has not been idle, and that it has endeavoured to prove itself worthy of the patronage it has received, the patronage that the Government has given to it, and also the patronage which it has received, in its improved position, from the officers of the army and navy, the militia, the yeomanry and volunteers. Since the improvement in our fortunes, we find officers of all the services coming in; there was a time in which we were compelled, as it is commonly called, to tout for members, now, on the contrary, we lie, to some extent, idle upon our oars; as far as that goes, we find the members come to us, instead of having to look after them. One word more, gentlemen, I am afraid I have troubled you almost too long; we are in possession, at the present moment of a very bad house, we hope to have a renewal of the lease of that bad house. But when the Thames Embankment, and other improvements which are proposed, are carried out, we hope to be in a more public position as it were, that is to say, the intentions are, that the house which is now occupied by Lord Carington, will come away, and then there will be a street from the Horse Guards, passing the Institution and leading down to the Thames embankment. It appears to me worth our while to consider, whether from the position the Institution now enjoys, it will not be desirable for the Council to propose to the members to make a very great improvement in the building of the Institution. You may depend upon it, that good as you may be in many particulars, excellent as your Institution may be, good appearances are never thrown away. For instance, I do not mean to say anything about the outer appearance of your house, but if your rooms are dark and low, if you have no opportunity of properly showing the various arms, models, and other objects that are within your walls, if your rooms are so small that you have not got the opportunity of classifying the different objects within them, why then, I think you lose a great part of the value of your Museum; you might much improve their exhibition by improving the building, and making it more in keeping with the great public benefit which the Institution confers. I fervently hope the time may arrive when the Council of the Institution will be able to propose that the building shall be pulled down, and a new one erected in its stead. To my mind, although it may cost a large sum of money to do it, yet it is a sum of money that will be well laid out, and will, in the long run, repay you for the expense to which you go. You will find if you have a well-managed Institution, if your Journal is still conducted in the manner in which I am proud to say it hitherto has been, (and to this we are much indebted to the exertions of the secretary, Captain Burgess,) if your Museum is so arranged that everything that the young officer, and even the old officer can want for the purpose of improving his general and professional knowledge, may be readily found, then you will find officers will come to your Institution and make use of your Museum, and make use of your Library. There is a gallant officer who was to have been here to-night, whose absence I deeply regret, I allude to Sir Edward Cust. Sir Edward Cust has lately produced a work, which, I think, is about as useful a hand-book as ever was produced by any writer, *The Annals of the Wars, from the beginning of* 1700 *up to the Peace of* 1815. It is as useful a work as any officer can place in his library, and Sir Edward Cust has mainly written that book out of the Library of the Royal United Service Institution. Besides, officers of the Artillery, and Engineers in particular, are constantly coming to the Institution, taking works out of the Library, either for their own information, or for the purpose of writing some historical essay, or some work of professional utility. Such instances show the great value of the professional library of the Institution; we find them coming there and availing themselves of its resources, by means of which their minds are improved, and they are able to communicate the information which they obtain to their brethren in arms, and

which information, in the end, must prove beneficial to the naval and military services.

Gentlemen, I thank you sincerely for the honour you have done me in asking me to meet you here this night. I can only repeat what I began with, that it is a compliment which I value most sincerely. I value it as coming from a body of men with whom I have been so long associated, with whom I have worked so cordially, with whom I am proud to say in conducting many difficult questions in which there has been a difference of opinion, during the whole time I have had the honour of a seat at the Council Board, I do not believe I have ever had an angry word, or a vital difference of opinion with any one member of the Council. I thank them, as I do most sincerely, for the support they have given me during the time they have done me the honour of placing me at their head, and I thank you at the same time for the honour you have done me in inviting me to dinner this evening, before I proceed to take upon myself that command to which I have been appointed in Canada. The deep interest I take in the Royal United Service Institution, will only be enhanced by the pleasure which I feel in having been your guest to-night.

Sir GEORGE BACK: Gentlemen, I have the privilege to propose the next toast, and when you hear the name of the gentleman I am sure that you will receive it with the utmost cordiality and enthusiasm. It is that of your eloquent president, the Right Hon. Sir John Pakington. Surrounded as I am by officers of both arms of the service, who delight to do honour to his name, permit me to deviate slightly from what has been said, and to refer to one occasion when Sir John presided over the destinies of the navy, and when he, with praiseworthy decision, inducted, if I may so say, a new era into our service in the class of large iron-plated ships. It required no small courage to do that, and that beautiful model and graceful form of ship, the "Warrior," will always be associated with the name of Sir John Pakington. We all acknowledge that he is no bad man who follows a good example, but he is a better who originates it. It may be in the course of time that Sir John Pakington will again assume the same high function, and whenever that time shall come we may safely be assured that he will always take a deep interest in the Royal United Service Institution, and I am glad to hear the right hon. baronet say how well he is disposed to place a "little something" in the naval estimates, and so give us an opportunity of enlarging the benefits of our Institution. I am not here to make a speech, therefore I cannot do better than propose the health of your eloquent chairman Sir John Pakington.

The toast was drunk with all honours.

The CHAIRMAN: Sir George Back and Gentlemen, I feel extremely obliged to you for the very kind manner in which the honourable and gallant admiral has been so good as to propose, and you have been so good as to receive, this toast of my health, in virtue of my momentary position as your chairman of to-day. Seamen are always brave, and I am not sure that any man can be of greater bravery than to indulge in prophecy. The gallant admiral has ventured to be a prophet upon this occasion, and he has prophecied two things. One is that I am to return to high office, and if I do, it is quite clear where I should go. Well, I am far from wishing to commit myself to any opinion now that the gallant admiral has not been rash. But he ventured upon another prophecy, and that was that if ever I should become First Lord of the Admiralty again, I should certainly introduce into the estimates a vote for the Royal United Service Institution. Gentlemen, this is really going a little too far, because all I have committed myself to, all that I can presume for a moment to commit myself to, is my own personal good will, my own personal good feeling, and I am all in favour of the United Service Institution. But you will remember the First Lord of the Admiralty, or the Minister for War, or the head of any of those great departments, when he is drawing the estimates is subject to two controlling powers; one is the Cabinet generally, and the other is the Chancellor of the Exchequer particularly. Therefore I would beg my honourable and gallant friend to reflect that before I can propose the grant for the Royal United Service Institution it will be necessary for me to consult the Chancellor of the Exchequer of the day, even if I should ever be in a position to consult any Chancellor of the Exchequer at all. Reverting to the occasion upon which I am now addressing you, I need not repeat the good feeling towards my honourable and gallant friend with which I undertook

the duty which I was requested to perform, and I may perhaps be allowed to state the extreme surprise I felt when I was requested to undertake it. In fact, I could only understand it upon two principles. One was a most sound and true one, namely, that nobody can feel more regard and more respect for my honourable and gallant friend than I do; the other was, that supposing, as it was a dinner by the United Service Institution, you might possibly have thought that a man, who having held office for a very short period in the aggregate, still during that short time, had been both minister for war and minister for the navy, might be considered to represent, to a certain extent in his own person, the United Service Institution. Whatever may have been the object, I have been very glad to accede to the request, and I am truly indebted to you for the kind manner in which you have drunk my health.

Colonel DUNNE, M.P.: Sir John Pakington, and Gentlemen, I have been directed to give a toast, which I have no doubt you will join in most cordially, for your meeting here to-night shows your interest in the prosperity of the Royal United Service Institution. I wish it had fallen to somebody, who is perhaps more able and competent than myself, but I will yield to no one in anxiety for its prosperity. From the very earliest period I have been a member of the Institution, and when it commenced, I had hopes that it would flourish as it has done, but the progress was very slow. I recollect in very early life, in Paris, having seen the Musée de l'Artillerie, and several of the Institutions established by French and foreign officers, that I certainly felt some shame in the literary state of the character of the British army. No army had equalled it in bravery or success in the field, but soldiers wrote very rarely, and for several years there was scarcely a publication on military subjects worth reading in the English language that was not a translation from some foreign one. But if you look back you will find in France, in the very earliest days of the Revolution, some of the most admirable works which would account for the very great success of the French arms. They were written, many of them, by men who subsequently distinguished themselves, and deservedly. There is a report on the Black Forest, by General Guilaumot, which to this day is worth the perusal, and anxious perusal, of any officer who wished to study the report of a country that is to be invaded or defended by an army. These things made me feel, at a very early age and period of the service, that this country wanted something of the kind, and I joined as early as I possibly could an Association for the purpose of promoting the literature and professional knowledge of the army and navy. But at that time it did not progress, and it was not for several years that it at all assumed the form it has now done. A great deal of this progress has been ascribed, and rightly ascribed, to my friend, General Lindsay, but I think we are doing something more than doing him honour this evening, we are doing much for the Institution itself, and by this meeting of so many officers who are distinguished, not only by the sword and daring actions, but by works of high literature and high intellect, we are actually forwarding the interests of the services. For many years, there is no doubt, the Government have taken very little notice of this Institution. In almost all these things we know that the Government of England is slow, but if it sees that an institution is useful, I think it is very consistent in supporting it. The War Office has supported it, and though my right honourable friend has not pledged himself, if ever he should be in office to do so; yet I have no doubt, that not only he, but any other person in the high situation of presiding over the Admiralty, now that this Institution has gone so much a-head, will find it for the benefit of the country and the services to do so; it is not an Institution of a few individuals, however high in intellect and art, but a National Institution. That is my conviction, and I am perfectly convinced that this evening is going one step in the right direction. I am aware that some years ago, a man anxious to improve himself in his profession, could hardly find a model, could hardly find any books of reference. Now you have a large library, you have it well-arranged, you have an admirable Secretary, Captain Burgess, to whom we all are much indebted for these arrangements. As I am speaking of the library, I wish to call the attention of the Institution to a library in a foreign country—Corfu. I hope if those islands are ceded, we shall not cede the library. I was for many years in that garrison, there is an admirable library there, and I hope whatever else is done, the library will be preserved. I had merely to say a few words. It requires very little eloquence, if I possessed it, to introduce the

toast of prosperity to the Society to which we all feel indebted. I am convinced this evening has done it great advantage, and that while we are doing honour to the man, we are doing honour to the Institution. We drink "Prosperity to the Royal United Service Institution."

The toast was drunk with all honours.

The CHAIRMAN: Now gentlemen, I have just filled my glass so full, that I do not think I could perform the well-known feat of putting a shilling into it, and I hope you will all follow my example. My honourable and gallant friend who has just spoken, and proposed prosperity to this Institution, has spoken to the bravery and success of the British army in the field. I am sure he is quite aware that the gallantry and the success of the British army and navy are not limited to the field, or at least are not limited to what we usually call the field, and that there are other fields in which they are equally successful. We are in the habit of drinking the health of the ladies last. I am sure everybody understands why we drink it *last*, not because it is *least*, but because we all feel that no toast would do after it. Gentlemen, I think you will agree with me that we ought not to break up to-night without drinking the health of Lady Sarah Lindsay. Like a good soldier's wife, she is going to share the fortunes of her husband in Canada. Let us hope for her, as for him, that she may return here to a long career of domestic happiness.

The toast was drunk with cheers.

General LINDSAY: On behalf of Lady Sarah and the ladies, whose health has just now been proposed by Sir John Pakington and so cordially received by yourselves, allow me to return you my most sincere thanks. It is quite true, as has been expressed by Sir John Pakington, that Lady Sarah accompanies me to Canada, and I can only say, I shall go out there with very much greater pleasure to myself with her accompanying me, than I should do alone. Whatever our fortunes may be, whether we have a quiet time, or a time in which there may be troubles, which of course, as friends to our country we may hope may not occur, I shall have the satisfaction of knowing I have the partner of my life there with me. She no doubt, if disturbances should arise, will be placed in safety, but at the same time I shall have the satisfaction of knowing that she will be there to share my fortunes with me.

Colonel BEAUMONT: Sir John Pakington and General Lindsay, you will excuse me for breaking through the arrangements of this evening, I myself am a Colonel in Her Majesty's Service, and have served in Canada, and have property there. I can only say as far as I am concerned, whatever may be the difficulties that General Lindsay may have to experience in Canada, he will there meet with a loyal population who will support him through thick and thin.

Evening Meeting.

Monday, February 16, 1863.

Captain E. GARDINER FISHBOURNE, R.N., C.B., in the Chair.

LIST of MEMBERS who joined the Institution from 1st January to 16th February.

LIFE.

Russell, H. R., Captain 57th Regiment.

ANNUAL.

Dillon, Hon. A., Depy. Lieut. co. Mayo.
Dillon, H., Ens. Rifle Brigade. 1*l.*
Mayne, J. O., Capt. Roy. Eng. Mad. 1*l.*
Blowers, W. H., Capt. Bom. Staff. Corps. 1*l.*
Heathcote, C. T., Capt. Bom. Staff. Corps. 1*l.*
Smith, J. H., Capt. R.E. 1*l.*
Mallet Hugh, Capt. late 4th Husrs. 1*l.*
Strachan, J. Lieut. 94th Regiment.
Armstrong, C. A., Capt. 10th Regt. 1*l.*
Beale, P., Capt. 10th Regiment. 1*l.*
Agg, T. F., Lieut. 16th Lancers. 1*l.*
White, A., Lieut. Queen's Westr. Rifle Volunteers. 1*l.*
Cartwright, R., Lieut. 15th Regt.
Green, G. F., Ensign 14th Regiment.
Owen, G. A., Lieut. 107th Beng. Inf. 1*l.*
Boyce, J., Lieut. 11th Regt. 1*l.*
Boulcott, J. W., Lieut. 86th Regt. 1*l.*
Walker, F. W. E. F., Lieut. Sco. Fus. Gds. 1*l.*
Jobling, F. C., Ens. Cey. Rifles. 1*l.*
Sidebottom, L., Major Unatt. 1*l.*
Torbet, P. G., Lieut. R.E. 1*l.*
Mottram, H. G., 4th Worces. Rifle Vols. 1*l.*
Colby, G. P., Capt. 2nd Queen's. 1*l.*
Gledstanes, H. B., Lieut. 75th Regt. 1*l.*
Crombie, Alex., Major 72nd Highrs.
Rice, C., Major 72nd Highlanders.
Tanner, T., Capt. 4th King's Own.
Thrupp, M. F., Ens. 4th King's Own.
Atkinson, T. G. B., Capt. 94th Regt.
Trevor, E. A., Lieut. R.E., Bengal.
Shepheard, W., Rear-Admiral. 1*l.*
Freemantle, E. R., Com. R.N. 1*l.*
Trower, C. T., Major 103rd Roy. Bom. Fus.
Clay, T. S., Lieut. 103rd Roy. Bom. Fus.
Hobart, Hon. H. M., Lieut. 103rd Roy. Bom. Fus.
Godwin, A. A., Lieut. 103rd Roy. Bom. Fus.
Sawyer, C., Lieut.-Col. 6th Drs. Gds. 1*l.*

ON THE FUTURE OF NAVAL ATTACK AND DEFENCE.

By Captain J. H. Selwyn, R.N.

My object in reading this paper will be principally to give opportunity for the full discussion of the important subject of which it professes to treat. I could not presume to dogmatize before an Institute of

professional men who must, many of them, be so much more competent than myself to express valuable opinions on the manœuvres and tactics, the instruments and their disposition, which are to make up the sum of future naval attack and defence. But for the humblest member of a profession, as well as for its greatest ornament, it is not only allowable to say, but also it is true wisdom to acknowledge, "I want to know,' and therefore I seek to elicit information, which may be alike valuable to the highest and the lowest, to the looker on as well as to the professional man.

That each branch of the subject may receive its due share of consideration, I have thought it best to classify them under several well-defined heads.

The first of these seems properly to be, the means of future manœuvring, or the motive power and its applications which are now, or seem likely soon to be, at our command for that purpose.

The second will comprise the means of attack; and the third, the means of defence, on which we may really and safely rely, while the conclusion will be devoted to the manœuvring proper, or the management of the resources on the ocean.

It is obvious enough that as regards the first subject,—the great thing to be looked for,—is not only the highest attainable velocity of motion, but also the longest attainable duration of this power, or as it is sometimes tersely put in racing language, not only speed but bottom.

Of late years speed has been sought by the more scientific formation of the body to be propelled, and very satisfactory results have in this manner been obtained, though I am far from thinking that as regards men-of-war we have arrived at a *ne plus ultra;* and if, as at present seems probable, we are to carry heavy defensive armour, I am disposed to think that the necessary velocity will have to be produced by a very great increase of beam, with a spherical form of bottom, rather than by that extreme length, which is as 6 to 1 in some modern ships, and has a tendency to render such vessels very unmanageable under sail alone. Under steam too, with the single screw, a greater length of time is required for turning; and the force necessary to be exerted on the rudder-head is such as scarcely any disposition of material will enable us to resist.

A paper which deserved most serious attention was read by Commander Symonds last year before this Institution, on the advantages to be derived from the use of twin screws, and both as regards increase of speed, and almost perfect facilities for manœuvring, I am happy to bear testimony to the confirmation which practice has since afforded of the truth of a great portion of the theory there developed. I may say that I have little doubt that those few points which have not yet received a trial, as regards the rudder, double keels, &c., will be found as satisfactory as was shewn to be the case by the experimental trip of the "Flora," with twin screws and independent engines. On that occasion, a speed of 14 knots was attained by a vessel of 350 tons and 120 horse-power, built for a tug, and consequently with anything but fine lines. She was repeatedly turned *on her centre* by reversing one

set of engines and going a-head with the other, and altogether gave results which astonished and delighted every one present.

But in her, as in all other vessels up to the present time, little comparatively has been done to secure the duration of these results, the most economically-constructed boilers expending all the fuel the ship is able to stow in about 12 or 14 days. Here then is a point where some improvement is most desirable, and I am happy to say I have recently become acquainted with a method of heating water, which promises to do much in this direction. It is not within the limits of such a paper as this, to give a full description of the method employed. It may suffice to say that it is the invention of Mr. A. Longbottom, C.E., and that it proceeds on the principle that if, as is well-known, water may be heated to the temperature of red-hot iron in tubes, without making steam,—no room being allowed for the generation of that gas,—then the greatest heating surface is to be obtained by copying the worm of the still (which affords the greatest cooling surface), and, in the words of the inventor, a vessel of considerable size may be driven across the Atlantic with no more expenditure of coal than would take a locomotive from London to Exeter. I do not claim perfection for this invention, I would not even be understood to pronounce an opinion on its merits, I only say, that "I want to know" if it is not well worth a trial.

For while we are quite ready to acknowledge that steam is and must be, till a new power is discovered, the right arm of our strength, we must not ignore the many difficulties which, in the event of war with an active naval foe, would attend the coaling of our ships with that certainty and ease which we now accept as a matter of course. The capture of half-a-dozen colliers proceeding to Gibraltar and Malta, might paralyze the operations of the Mediterranean Fleet. Therefore economy of coal has even a greater importance than the money and time questions involved, and a supine neglect of it during peace will, as in all other cases, bring its own punishment in the first years of a war.

I turn now with great diffidence to the much-vexed question of the means of attack, and I cannot help saying that I look with grave mistrust at some of the so-called improvements in our naval artillery.

Three objects seem to have been sought, alike by Sir W. Armstrong and Mr. Whitworth, besides a host of other non-professional inventors, or rather advocates of certain forms of artillery. I have yet to learn that there is much which can properly be called invention in most of these systems, more especially as in the Isle of Man, round Peel Castle, are to be seen rifled ordnance to the number of 30 or 40, which have been consigned to the ignoble duty of posts, half-buried in the earth. We must hope that one or two of these, or at any rate, a full description of them will be obtainable for this Institution, they are supposed to have been cast in the time of Cromwell. Extreme accuracy, long range, and penetration as distinct from destruction of iron plates, these seem to have been obtained, while much that was far more likely to be useful has been left uncared for; not only so, but points of acknowledged importance have been given up, and we are

told to be content with long range instead of initial velocity, with segment shell, instead of spherical case, with weapons that cannot bear the rough usage of those elements we ourselves must always be called upon to face; guns which, in the event of the ship getting ashore, must be put into oil-skin before being tumbled overboard to lighten her. Science, too, has been set at nought in the shot, and her teaching that iron in contact with lead is always destroyed by galvanic action in water, still more in salt water, is either ignored or studiously kept in the back ground.

Again, penetration of iron plates of enormous thickness (when considered with reference to the carrying power of ships) has certainly been lately obtained, but a broadside of 68-pounders, concentrated, as can always be done, would probably *destroy*, not penetrate an iron plate of similar size at a similar distance, owing to their initial velocity (as must always be the case with spherical bodies) being considerably greater. And here I would remark, that it seems strange that any doubt should have existed, that any experiments should have been deemed necessary to establish the fact, that of bodies of a similar weight, of the same substance, similarly propelled, the spherically formed one as it will have the greatest area, will also have the highest initial velocity and, *cæteris paribus*, the shortest range. It will also have the greatest contents, whether of molten iron or bursting charge, and, therefore, as a shell, no other form can be advantageously substituted for it, unless, indeed, in a case such as long range being absolutely required, when its advantages in other respects are no compensation for its deficiences in this. This, therefore, is a point on which a compromise should be sought; but, if I have to protect a disembarkation, or the reverse, it will be small consolation to be told that my rifled gun will hit a field officer three miles off, if from it I cannot, on occasion, fire a shrapnel shell that will annihilate a troop of cavalry at a thousand yards. I had far rather knock a plate off an armoured ship than penetrate it with any number of pretty little round holes; and, above all, I strongly value the capability of standing any usage that may be unavoidable in the rough conflict of the elements with the comparatively feeble works of man on the ocean or in the field.

If such objections were simply an invidious fault-finding, without any probability of means being discovered to obviate these inconveniences, to eliminate these errors, then indeed I had better have been silent, I ought not to have complained. But it has been ably shown how we may obtain a sufficiently long range, without sacrificing that initial velocity which forms so important a multiple of the weight of the shot, in estimating the effect; how, we may secure a considerable degree of accuracy without losing the rough-and ready character of the weapon—how to make guns that will fire any description of projectile, spherical or elongated, that may be suited to the particular case, and, at the same time, strong enough, without resorting to highly expensive twisted or *built-up* barrels—how, in short, it is not necessary that to obtain a very large measure of the advantages sought, we should give up any of those already attained. Need I say

that I refer to the systems proposed, and, to a very great extent demonstrated, by Commander Scott, R.N., and Captain Blakely, R.A., two practical men, who knew what was to be sought, and, therefore, soon found how to seek it—who had seen and studied the use of the weapon they wished to improve, and who knew therefore what they could, and what they could not, give up or obtain. They did not seek, as the principal object, a range and accuracy which alone were practically valueless. They did not imagine that ships were always steady, or that the destruction of a single man justified the expenditure of fifty pounds' worth of powder and shot; and more, they did not profess breech-loading and mechanical fits, and then shunt into muzzle-loaders and transcendental curved bores. But I gladly quit a part of my subject which has cost the public brains so much cudgelling, and the public purse some four and a half millions, hoping that the next generation may thereby be made wise enough to believe professional men on professional points, unless just cause can be shown to the contrary.

We are now to consider the question of defence against the formidable attack which, whatever may be justly said of the comparative merits of the various systems proposed, it is fully evident we must prepare to guard against in any future war. Is it possible by any weight of armour which, on the present system of iron plates, we can carry, to keep out the shot, not to say shell, which will be directed against us? Are we prepared to stand a dig under water? a kick on the bottom from a ram, or even a butt on the ribs from a 14-knot steamer? It seems very doubtful whether guns will come into play at all at close quarters, for by many and constantly recurring examples, we may learn that of two vessels coming into collision, the one run into is often sent to the bottom, with comparative impunity to the other.

But passing over this for the present, let us examine the effect likely to be produced on armour plates, such as at present exist, by a concentrated broadside at 200 yards of a vessel carrying 68-pounders on the maindeck. Strange it is, that even now, with all the experiments which iron-plate committees have tried, they have never, so far as I can learn, tried this, so that we have still to theorize on the subject.

I find that four 100-pounder shot fired, not together, but consecutively, broke through into the cupola of Captain Coles; that several shot together, as regards the place of striking, injured the plates very much, that on one occasion when six guns were fired as a salvo, the effect was enormously greater, as might have been expected, than when the same guns were fired consecutively; but on no occasion can I find that anything like even a heavy corvette's broadside was concentrated and fired at an armour plate.

Now, this is the very first expedient or experiment which would probably be tried in war, and till we can say that it has been fairly examined into, we really know nothing of the true value of armour. Therefore I say again, "I want to know." I fully believe, that such broadsides so delivered would, in a very few minutes, strip the ship

attacked, of almost the whole of her costly defence. True, she might be doing the same thing, and, therefore, inflicting as much damage as she was called upon to suffer. But this ought to be rescued from the region of conjecture, we ought to *know* what to expect on such a subject.

A most interesting metal has now come into practical use, which is known as aluminium. Its cost is certainly an objection at present to extensive experiments, but need be no bar to a consideration of its theoretically valuable qualities, none indeed to experiments on a small scale, which, I believe have not yet been made. About the metal itself there are these peculiarities:—Its melting point is not high, it melts at the bright red-heat of iron, it is very soft, almost as much so as lead, but what is of most importance, it is of remarkably low sp. gr., approaching to wood. Now, an experiment might easily be tried as to its power of resisting bullets, and if it approached to lead in this respect (supposing the resistance offered by that metal be not due to high sp. gr., more than to softness) it would be well worth while to consider how the supply would or might be increased, in answer to such a demand; for the source from whence aluminium is derived (the cryolite of Greenland and the clay shales) is for all practical purposes unlimited, and the only reason for its high price is the small quantity which can be sold at a profit. Here again it would be well to know—it is folly to remain ignorant.

As regards the system of defence advocated by Captain Cowper Coles, while I admire it on an unsinkable raft and in gunboats, I confess to have many doubts of the economy of putting a ship of 3,000 tons to carry six guns, big though they be; and of the wisdom of a system which relies on no saucy gun-boat getting under your bow or stern, where you are totally unable to fire at her. I think for its real development it requires an entirely different form of vessel, and is then most applicable to coast defence, where it would undoubtedly be of great value.

Besides armour, there are some other methods of meeting naval attack which require mention; among these is the defence of rivers against gun-boats, which the American war has taught us must by no means be neglected in such countries. So long as gun-boats are constructed with comparatively thin iron bottoms, a most formidable means of defence will be obtained by copying the snags and sawyers, hidden foes of ordinary river boats which nature teaches us are greatly to be feared. In a thickly timbered country, with, or even without iron shoes and spikes, these may easily be laid in a river in such numbers, and in such places, as to render it almost a certainty that the enemy (who has no chart of their whereabouts) will run upon them, and, of course, the heavier the boat with armour, the more would be the damage done. They have the advantage (or disadvantage) that as the river rises or falls, so do they also, always keeping the points down stream, and just awash. Nets, too, as Commander Symonds was one of the first to state publicly, will always be formidable as auxiliary means of defence, detaining screw ships in narrow passages under fire, and, perhaps, causing them to run aground in a tideway.

As regards the defence and attack at sea, that will more properly come under the separate head with which I now propose to conclude this paper, premising that throughout I have considered it as, and intended it to be, one to invite discussion of the points referred to, not to exhaust the arguments or facts connected with them. For of both of these, I know the members of this Institution to be in possession of a far larger store than I could hope to offer, and waiting only the opportunity I seek to give, for its publication.

Supposing war with a naval power were declared to-morrow, how should we manage our new means of attack and defence, comprising a power of motion at will in any direction, the use of which we never had any opportunity of fully testing during the late war, and a range and accuracy of projectile which, at that time, we had not fully attained. Our weak point is not so much our liability to invasion, which might be met in part by a coast telegraph, and would not probably be of any permanent injury, though fearful enough to the defenceless population at first, but in our wide-spread commerce; we could not afford for a day to see the command of the sea pass from our hands. The Americans have learnt how commerce leaves the flag and ownership which is liable to predatory attack at sea. The "Alabama" (to take an example) has caused more annoyance in New York than all the Confederate generals. She no sooner sees an American sail than she chases it, and her speed soon places it in her power. No soul can tell her place on the ocean, for she is not limited by the accidents of wind and weather, and she can as easily avoid a formidable foe as catch an unresisting prey. True eagle of the ocean, her captain may truly say with Byron, as far as his enemies are concerned:—

> "These are our realms, no limits to our sway,
> Our flag the sceptre, all who meet obey."

It follows then, that for whoever obtains and keeps the empire of the ocean there are now more than ever immense advantages in prospect, but for those who rely, as England does, more on their commerce than on any other source of prosperity, there are also immense dangers to be feared. We cannot pay too dearly for any means of securing that speed and bottom of which I first spoke, and without which, brave hearts, good guns, and triple armour are alike useless. We shall never be able again effectually to blockade a port. The silent screw will take advantage of a dark night or fog, and will slip to sea to harry the commerce and distress the finances of her enemy, till a faster ship than herself is enabled to force on a combat, which, like a privateer of old, she will decline until that moment arrives. So much for the light cavalry of future naval warfare. As for the tactics of a fleet, I can only say that I think, far from assembling in large numbers, and so, united, fighting an action on the old system of line-of-battle and line-a-head, the true tactics to be initiated by the weaker as a rule, is a trial of speed and bottom. If, for instance, a fleet wished to go out of a blockaded port, and then to damage the enemy more effectually by separating than they could ever do by remaining together, it would be easy to secure a time when many of the

blockading fleet having been under steam to keep position, their supply of coal would be lessened, and they would therefore be on unequal terms for engaging in such a chase as that of Nelson to the West Indies.

If, again, the fleets did meet, a very short trial of speed would draw out the faster ships from the others, and they might be overcome in detail, or failing that, if they kept together, the hostile fleet might leave them "alone in their glory," and pursue more profitable occupations than that of seeing whose skin was the hardest. Not till we had cut off every port at which an enemy's steamer could coal, should we put an end to this annoying state of things. Therefore such islands as the Ionian are not to be given up carelessly. It might be said, this applies as much to one fleet as the other—as much to other commerce as our own. True enough, if we have no more slow ships than our neighbours, which has not always been the case. True, if others depended as much as we do on commerce, but in any case new modes of action will come with new means, and it would be well to think of what we shall do before the time comes for doing it.

The question between ships and stone walls is remarkably changed by the new means of offence. It must now never be forgotten, that a ship is a small, moveable target, and a fort a large fixed one, that every shot from a ship may, probably will, hit at a distance from whence she may defy, under steam, any gun in the fortress to touch her; that walls and magazines may be damaged and blown up by such an attack, and that no iron casing on the sea face will prevent the distant fire from overtopping the ramparts and plunging into the barracks and dockyards. I confess I am one of those who think, that to a peculiar class of vessel, unsinkable by rams, and of moderate speed, must the defence of our sea coast be principally committed, to the exclusion of those enormous forts whose contract brick would in some cases be a poor defence against any form of rifled gun, and whose extent only ensures that no enemy will ever come near them while he can find a sandy bay anywhere else, though they must be garrisoned for fear they should prove places of strength, not against, but for the enemy. As frigate and corvette actions will probably play a most important part in any future naval war, I think forethought on the manœuvres then to be employed will be especially necessary and useful, and if no other member turns his attention to this point, I shall be happy to try to gather facts and probabilities together for that purpose, and at some future day lay them before the Institution.

I will now close my paper by thanking you for the patient hearing which you have given me, hoping that what I have put as doubts will receive their solution from those who can better furnish us with facts and illustrations bearing on the subject, so that I and others may, by the operation of this most useful Institution, become acquainted with the best professional opinions on points so nearly and highly interesting to all of us.

The CHAIRMAN: It will be more convenient for all parties that the discussion should be confined to the division which Captain Selwyn has adopted in his paper.

The first part of the paper relates to motive power; if any gentleman wishes to make any remarks upon that subject we shall be glad to hear him.

Commander SYMONDS, R.N.: It is a source of peculiar gratification to me to have had this opportunity of hearing the remarks that I made on a previous occasion, with respect to the double screws, so spoken of by my friend Captain Selwyn, in whose company I had the opportunity of witnessing experiments with two screws on a recent occasion, especially as there were several doubts expressed on reading my paper, at this Institution, as to the fact of two screws having that most extraordinary steering and manœuvering power which I then described.

Captain Selwyn has made use of one word which is a slight mistake, I think. It was not a "theoretical" deduction of mine, but it was the result of practice some five or six years ago, which brought me to the conclusion that the use of two screws in a ship of war would be found most advantageous. On that occasion I witnessed much greater results in a little vessel of 100 tons, than were ever seen in the "Flora." The "Flora," although obtaining very great results, was not by any means a vessel well suited to the trial of the principle. In the first place, she was built with a very deep gripe, and in the next, she was remarkably high out of the water, with very high deck cabins, and there was a larger area of resistance to turning in her, probably, than in almost any vessel that has had two screws fitted. Still the results, as Captain Selwyn said, were very remarkable. She, on many occasions (tried both ways), turned on her centre. That was really a point that surprised me, because I found in the vessel that I saw tried before, that she turned on a point about one-third from the screw; whereas in this case the vessel certainly turned on her centre. The speed attained by these two screws was considerably greater than is generally obtained from a similar vessel with a similar proportion of power. There is no doubt that she did obtain a speed of fourteen knots an hour. Therefore, one of the arguments used against the use of two screws, on the occasion I refer to, falls to the ground.

Although the "Flora" was so successful, both in her manœuvring as well as in her propelling power, still I did not consider her the type of a twin-screw steamer, suitable for a man-of-war. She is a single-keeled vessel. I should say in the first place, that the shafts of the "Flora's" screws come immediately from the counter, and at a distance of some ten or fifteen feet they are supported by V brackets, which are very well calculated to foul; moreover, I think the vibration that was perceptible on board of her was increased very considerably by having the screw at the end of so long a lever. In addition to vibration, they are obviously liable to a variety of accidents.

For these reasons, I have (on the occasion before referred to), recommended another method of fitting the two screws on a principle which has been for a long time advocated by my friend Mr. Richard Roberts, the celebrated mechanical engineer, and which I have assisted him in applying to war ships. Instead of carrying the shaft out from the quarter, if you observe, as in this model, there is a trunk which is connected with the counter by a web of iron, and the screw fits immediately to the end of this trunk, so that literally the trunk and the web form a portion of the hull, thus adding to the strength rather than detracting from it; this, in addition to the two cellular keels, will give a very considerable amount of strength to the ship's bottom, and also will have the very great advantage on taking the ground of keeping her upright, and protecting the bottom from rocks or snags.

I shall not farther dilate upon this plan, except with reference to the action of these two screws. I must observe, I quite coincide with Captain Selwyn, that although not entirely disagreeing with the cupola principle, still, I beg leave to say, this is another way of arriving at the end that Captain Coles professes to attain by his cupola. I think very probably his cupolas will be of great service in some cases; but at sea, where you want to bring your guns to bear rapidly, nothing can be so certain as the action of two screws. We must bear in mind, that it is quite possible we may have to use both our broadsides at the same time. In a vessel with two screws you may retain your broadside guns, and, if you have an enemy on each side, you will find them very useful; whereas with the cupola ship, having only her five guns, she will have a very short supply of guns to fight both sides with. I firmly believe at sea, that the broadside guns may be brought to bear much more rapidly with the two screws than by any mechanical means that can be applied to a cupola.

I think many professional men agree with me on that point. Moreover, a cupola ship, having only one screw to manœuvre her, is just as liable to be run down by another ship, without being able to avoid it, as an ordinary single screw steamer. Now, I conceive the two screws will enable you to receive the blow of a ram in a glancing direction, because the action of the screw is instantaneous. We know perfectly well, that in the smartest ship, the action of the helm is not immediate; it takes some little time to gather its effect; whereas by the slightest reduction or increase of speed on one of the screws the ship is acted upon instantaneously. The great agent in this case is the independent and separate engine. We have very often heard of two screws being applied to ships in years gone by, but they were comparatively of little use, being geared together. However, since the introduction, which I believe is due to my friend Mr. Roberts, of the separate and independent engine to the screws, they are turned at will, in either direction, and the manœuvring, which I have described, is rendered possible, which it was not before. There is this advantage also in having the independent engine, as we saw illustrated in the trial of the "Flora." When to leeward in one of the bends of the river, with a strong wind and lee tide, one of the engine bearings heated. Had it been a single screw ship we should inevitably have gone on shore, but, by increasing the number of revolutions of the other screw, she came off at one-third less speed than with both.

There are various other points which, if time allowed, I might bring to your notice, but I think at the present moment I ought to confine myself to the remarks that I have made.

The CHAIRMAN: Has any other gentleman any remarks to make upon the subject of motive power?

Admiral Sir GEORGE SARTORIUS: I am very much pleased to see a young man like Captain Selwyn occupying himself upon a subject of such deep importance to his profession and to his country, and bringing to our notice the necessity of applying to practical men to correct the theories of those who are not practical. For I believe, that half the mischief that has occurred, has arisen from neglecting the opinions of practical men.

With respect to the subject of motive power, the application of the two screws is a most important one to sailors. It gives us what is of the highest importance—the facility of guiding a vessel with much greater ease than we could do with the rudder, and under circumstances when the rudder could never act. If we succeed in casting very heavy guns, and I have expressed my opinion on the subject, in a pamphlet published a few months ago, it will be by means of two screws that we shall be able to use the heaviest guns by making the ship herself the gun-carriage. This anticipation of mine is very fortunately realised in the clever and ingenious manner in which the two screws will be applied. Whether it will be on Captain Symond's system, or on the system applied to the "Flora," does not matter.

Captain SELWYN: That is Captain Symonds' system. Mr. Roberts' and Captain Symonds' system are applied in the "Flora."

Commander SYMONDS: Our system of the independent and separate engines.

Admiral Sir GEORGE SARTORIUS: For us in the navy it is a most important discovery. It enables every offensive power we can make use of to be much more readily managed. We can have the largest guns put on board ships which are themselves made the gun-carriages. The pointing of the gun will be given by the screw of the vessel. The raising and depressing of the gun will, of course, be done inside, but the difficulty of training such great guns will be overcome by the screws. In that way, the ship will form a ram, a most powerful battery, and probably that will be the type which our future vessels of war will assume. I can say nothing more with regard to motive power. In the observations, Captain Selwyn has made, I heartily concur; there is hardly a point that I disagree with him upon, except that I think he attaches too much importance to the ship as against a battery.

Lieutenant NEWENHAM, R.N.: I would speak with regard to the fuel employed in ships-of-war. That is a very essential part of the motive power. If any gentleman is in the habit of going up and down the river frequently, he will see in the river steamers an immense quantity of smoke issuing from the funnels. Now, I need not tell you, that when that occurs, there is an immense quantity of fuel wasted. If, therefore, we can devise any plan whereby the fuel may be economised, that will

be a great advantage, especially for ships-of-war, where the ships have to be a long way out at sea, and a long way off any means of getting a fresh supply of fuel. It is quite true if engineers are properly instructed they can so trim their fires that the smoke need not escape, that in fact you may burn the fuel with great economy, and that no other arrangements need be employed than a proper mode of stoking. But we know practically that this is impossible to be done. The Peninsular and Oriental and the other large steam-boat Companies have given this question a great deal of consideration, and they find it perfectly impossible to make stokers economise fuel. I believe even premiums have been offered to them as rewards for endeavouring to work with a small quantity of fuel, still without any successful result under ordinary circumstances.

Now civil engineers know very well exactly how much water a pound of coal ought to evaporate. That is a fixed point which is perfectly well-known. Then the question is, "Can we obtain any other fuel than coal which will give us the results that we wish to obtain, and which will put it almost beyond the power of the stokers and engineers, or engine drivers to waste the fuel in the way they do at the present moment?" You will see that that is a very important question. I think it may be done. From experiments I have seen carried out, I think if certain kinds of coke were employed we should arrive at a result which would be very satisfactory. We know that coke is employed in locomotive engines, but it has been employed there almost because it was absolutely necessary, even considering the immense extra expense that it occasions. But it is quite possible to make coke, for instance, from peat, by a process that has been recently patented, and which seems to offer very extraordinary results. I believe some experiments have been lately tried upon a coke that was made under Butler's process, in which he condenses and chars the peat only to a certain extent, and he has been enabled, I believe, with something like 12 cwt. of this patent peat coke to do as much work as nearly double the quantity of coal under the ordinary system.

The CHAIRMAN: Could you give any estimate of the weight of coke per cubic foot, because that will be one of the difficulties, as compared with coal?

Lieutenant NEWENHAM: The value of this coke, if I am rightly informed, is something like 12*s.* a ton, not more.

The CHAIRMAN: But coke is very light, and would occupy a very large cubical space as compared with coal?

Lieutenant NEWENHAM: Not necessarily so. The question is as to the amount of tonnage. Suppose you take 100 tons of space in a vessel, how many miles or knots can you get out of that tonnage of fuel. That I take to be the question. It is not a question as to the cost of it. I was going to say, that so far as I can understand it, this coke offers advantages on every side. First of all, it is less costly than coal; secondly, it will have more power, a given weight will do a good deal more work.

The CHAIRMAN: Would a cubic foot of coke generate as much steam as a cubic foot of coal?

Lieutenant NEWENHAM: Oh, certainly, considerably more.

A MEMBER: May I ask one question? I wish to ask the gentleman who spoke last whether it does not require to increase the draught when burning coke instead of coal?

Lieutenant NEWENHAM: It requires very much less draught; that is a very curious thing. It is a remarkable thing. I am glad the gentleman has reminded me of it, because it appears that you can burn this coke or any kind of peat coke with a very much less draught than the ordinary coal; in fact, you could reduce the smoke stack of a steamer to about within ten feet of the deck, which I apprehend would be an important thing in sea-going vessels.

The CHAIRMAN: As I was present when Captain Symonds read his paper, I can confirm what he said about the difficulties that were raised, and the statements that were made by shipbuilders, that the double screw had been tried and failed; but really the more I hear and the more I see, the more I am inclined to mistrust the statements that are made about experiments having been tried. I find that a very small difference makes the whole difference between success and absolute failure. When it is stated that a thing has been tried, we want to get the whole of the details, because somehow

or other, whether for want of the capability of observing in the persons who made the experiments, or some other reason, they are pronounced to be failures, when they are not so, and to be successes when they are far from being so. This subject of coke is a very interesting one. If it be true, as stated, that a cubic foot of coke will generate an equal quantity of steam with a cubic foot of coal or more, it is an important subject, because one of the great difficulties of ship-building is the enormous changes in the draught of water occasioned by the great consumption of coal, and consequent reduction of weight. The failure of the "Sidon" was due to that. They sought a large quantity of stowage for her coals, and, overlooking the consequences that must necessarily arise from the mode by which they obtained it, they spoilt the ship; this might have been avoided by a little forethought. I must confess, with respect to the double screw, I, myself, thought it would not give the very great results that seem to have been realised by the vessel alluded to; and if she realised these great results at 14 miles an hour, I take it that the result she will realise at sea, will be relatively greater, arising out of the fact of the increase of surface which two screws afford, as against one. The great disadvantages of sea-going screw vessels of course in long voyages with head seas is, that the screw travels very fast, and they burn as much coal when they are not going a-head as when they are going at a very great speed; this is a very serious objection to the screw. The paddle has that advantage over it, and we may expect to find vessels with double screws making economical sea-going packets, which is not the case now, for when these vessels are subject to a head wind or a head sea, they burn an immense quantity of coals without making any progress.

The second part of the paper is on the subject of offence which will comprise the means of attack. Has any gentleman any remark to make upon the subject of attack and the means of attack?

Captain YONGE, R.A.: In case no other gentleman will favour the meeting with any remarks upon the subject, I should like to throw out a hint which I think is lost sight of by Captain Selwyn, and by a great many naval officers, in treating this question of naval attack. I know I am treading on dangerous ground, and I candidly confess it is not a point which I have considered to any great extent, but I think the great mistake made by the officers of the naval profession is the notion that they will always be able to find an enemy who will allow them to close with them. Now we all know, I think it was at the battle of Trafalgar, after sundry orders had been given, Nelson said that no captain could do very wrong who laid himself alongside a ship of the enemy. That was all very well in those days, when there were reasons for going alongside an enemy's ship. I leave altogether the question of the natural desire of the sailor to come to close quarters, but looking at it merely as a case of matériel, the guns they had at that period were not guns that would enable them to do any damage at any but short ranges. The favourite gun of the period was the carronade, a gun of very large calibre. The shot had great smashing effect, and the charge that was used was a very small charge indeed,—I think for some of the larger 32-pounders something like 2lbs. or 1lb. 10 ounces. It is impossible to do any damage with that shot and with that charge except at very close quarters. Then, again, it is no disparagement to the service, to say that in those days there was very little attention paid to naval gunnery. A gun was loaded and a gun was fired, and if it hit, so much the better, but I think that the science of gunnery entered very little into the details of naval actions. I am not prepared to say at what ranges those single actions or duels of the navy have been fought, but I think it will be found that if our then opponents, the Americans, had the opportunity of keeping us at a long range, they did so. They had long 18-pounders and other guns of comparatively long range, and they never allowed, if they could possibly help it, a British ship to close with them; and they commenced by dismantling the rigging, and then in detail doing all the damage they possibly could with deliberate long shots and steady gunnery. I think those days will never come again, in which naval officers can bring their ships alongside the enemy in the same way they did before.

Therefore, starting with that impression where "the wish is father to the thought," naval men find that a very good gun for these short ranges is the old 68-pounder, in fact, the old smooth bore gun, throwing a very heavy shot, and which has, as is well known, very great initial velocity. This is a point on which I think

many mistakes are made—in speaking of *initial* velocity. One would imagine that the shot struck its object immediately *on leaving the muzzle of the gun;* that is true *initial* velocity, but people lose sight of the fact that in the case of round shot it rapidly loses that velocity. The range of 600 yards is a very convenient one pitched upon. You hear of 3, 4, 5 and 600 yards, but hardly anything beyond. That is a very convenient range for the gun now in question. Therefore at that range they say very truly that a smooth-bore gun has very nearly as much effect as a rifled gun; but go a little farther—I think it is not quite fair to stop there and say, "We shall engage at 600 yards and no farther." There are two parties concerned in that question. You will have to see whether your enemy will let you come within 600 yards. If he have a good rifled gun, throwing a large shot at a thousand yards, and can make good practice at that long range, he will not allow you to come within 600 yards. Therefore I think Captain Selwyn, in the commencement of his lecture, was rather hard upon the rifled gun, in throwing it over and ignoring it in future actions.

Captain SELWYN: I did not by any means throw over rifled guns, only some peculiar forms of rifled guns.

Captain YONGE: My impression is, you mentioned that rather extreme case of hitting an officer at three thousand yards off as an instance to show that a rifled gun was of no value, considering that as an instance in which you stated that a long range was of comparatively little importance. I think a rifled gun will be of consequence for the simple reason that the enemy will not allow you to close. That is one very great consideration in the case of ships attacking each other. I think a ship which has a gun which will hit at the longest range, has a very much better chance of success, either of driving its enemy off, or of doing damage, than the one which is obliged to close before it can bring its guns to bear. Therefore, the improvement in guns is very important in order to keep pace with the improvement in armour-plates. In the case of broadsides I do not know how far the experiments at Shoeburyness did go into the question, but I think on one occasion there were four or five guns fired together as a salvo. In the days of wooden ships, when a shot made a hole in a ship, the consequence was, if you had a broadside, you had some forty or fifty holes made, and very considerable damage was done. You could not plug fifty holes as easily as you could plug one, but in these days you cannot make a hole at all. I think it is as difficult to make one single hole as it is to make fifty, therefore a broadside is no longer of such value as it was formerly. You can no longer with 68-pounders send a ship to the bottom; you may break her plating, but nothing more. That is not so satisfactory, I fancy, as it would be if the ship should go to the bottom before anybody had time to look about him. All I want to advance is that the long-ranging gun, of course a powerful one, is a very important item of consideration in such questions as these, and it has hardly received the prominence which it deserves in the very interesting paper read by Captain Selwyn.

Admiral SIR GEORGE SARTORIUS: I must agree upon one or two points with the last speaker, and disagree with him upon others. The gentleman said that the carronade was the favourite piece of artillery with us in my young days. We always looked upon it with a great deal of contempt. Every ship, both two-deckers and three-deckers, had long guns on the lower deck, and long guns on the main-deck, and very few guns indeed on the quarter-deck. Our brigs, and small vessels of that kind, were obliged to adopt the large diameter which the carronade gave, because they could not carry the long guns, and the very light long guns were inferior in practice to the carronade. I also agree with him that gunnery was entirely neglected. In a brig that I commanded, I had the ship's company of a frigate, that had been four years together, put on board her. The very first time I came to exercise the crew, one man lost three fingers, and another four, in firing a carronade. In a line-of-battle ship that I was in at the battle of Trafalgar, the only one throughout the whole of the navy, with the exception of the ship commanded by Lord Exmouth, then Captain Pellew—she was one of the very few, perhaps one of the four or five, that had been constantly exercised at her guns—at the battle of Trafalgar a line-of-battle-ship ran alongside us, her yard got entangled with our main rigging, and in the course of six-and-thirty minutes, from the extreme rapidity of our firing, we managed to knock away all her masts, and to kill and wound 436 of her men. Had we not been well-exercised at our guns, I think the Frenchman would have got the advantage of us. We had actually

our engine playing on her broadside to put out the fire caused by the flame of our guns. With regard to rifled guns, I confess I am inclined to side with Captain Selwyn. I heard one of the officers on board the "Excellent," observe, that when they were firing at a mark, there being no wind, and the tide keeping the vessel perfectly steady, they were sure of hitting it, but immediately the wind was a little too strong for the tide and the vessel moved about, although the water was nearly as smooth as this room, there was a considerable difference in the correctness of the aim. Now just imagine what would be the case in an action at sea, firing long shot. The slightest motion disarranges the aim of the gun, and no action ever has been decided, or will be decided by long shot at sea. We have also found that in every action of the enemy, whether with the Americans or with the French, the shot of the largest diameter carry the day. We have hardly an instance of an English 12-pounder frigate, that was not taken or beaten off by a French 18-pounder frigate, and in the American combats the Americans had 24-pounders to our 18-pounders. Therefore, the diameter of the shot is of the utmost importance, because the largest shot makes the largest hole, and it makes a great many more splinters. I do not say it may not occasionally occur that a gun of a long range may be of use in bringing-to a chase, or in perfectly smooth water, when combined with military operations on the shore; but for all practical purposes, the gun of largest diameter, with the highest initial velocity, will be the kind of gun which will be of the most service in naval warfare. But rifled guns, to be able to have an extreme range, must be of a very small diameter, and the oblong shot will do very little mischief. They make gimlet-holes without doing much mischief to the ship, either to the mast or rigging or to the hull. But I think the development of artillery has far exceeded already the use of the armour-plate. I think we have gone beyond the thickness of armour-plates that can be made use of for any practical purpose. I think we never can have—and the very information we have received to-day proves what I have mentioned before in my little pamphlet—that we never can have any more blockading. If it is a military port—I do not mean a commercial port—there are so many advantages on the side of the blockaded coming out suddenly and falling on the blockading squadron, that it will be almost impossible practically to blockade. The question now of the deepest interest to us, and on which must hinge all the subjects we have been treating of, is what is to be the form of vessel we are to have for our future warfare. The largest diameter of shot is of great importance, but then what kind of vessel are we to make use of? The question of attack and defence apply to each other. The largest shot, whether for attack or defence, is important, and also the kind of vessel we are to have at sea for the purpose of carrying those guns. These are the points which I earnestly hope all my friends here, both military and naval, will turn their attention to. We have not yet got that form; we have not yet come to the extreme development which artillery is capable of, and until we have done that it is hardly of any use theorising as to particular shot or particular guns. Let us find out which is the kind of gun best fitted to carry the largest shot, and what is the largest shot which may be made use of for practical purposes. That, I trust, younger heads than mine will do.

Rear-Admiral Sir EDWARD BELCHER, C.B.: I consider that the fastest ship has the greatest advantage of coming up with her enemies, and if we are to pursue the system of the ram, and to use the important power that we have of running over our adversary, and also of using our bow guns, I think that the rifled gun and the long shot will enable you probably to cut away your enemy's steerage, before you come to the point of coming alongside; which plan, I think, now will be obliterated from our mode of attack. I disagree with the idea of the projecting prow below water, because, if I had to engage an enemy, to chase him, and come up with him by sheer running; if I attempted to run my bow under his stern, he running from me, I must run my nose under water, and, therefore, I object to that form of bow. I prefer the bow cut away, similar to the steamers that we had in the Arctic expedition. I know that one of these vessels running against a body of ice, calculated as an inert matter to weigh about seventy or eighty thousand tons, ran her bow up on the ice without any particular shock, did not even spoil the crust of the port wine. She failed probably in the first charge, she retreated, tried it again, at a distance of half a mile, probably effected a crack, and the third time entered the crack, lifted herself bodily on the top of it, and separated the ice. Now, if a vessel of 350 tons, with merely common iron-shod bows can do that,

I consider the same vessel getting a fair run at his adversary's beam, and lifting one-third of his weight over his adversary, would be able to press him down into the water with the super-imposed weight. I am thoroughly satisfied as to the result, from all I have known of ships running into each other, particularly in the case of the "Révolutionnaire" running into one of our line-of-battle ships at Naples; it was not even running into her, but merely from a chop of the sea, she cut her down to the water's edge, without any running at all. Now, if that frigate, merely by a chop of the sea, could cut down a line-of-battle ship to the water's edge, I am perfectly satisfied, that if she had gone at her with her full force, she would have destroyed her; and I am perfectly convinced, when we come to fight these vessels, if we can only get a chance of running at them either at the bow or the stern, by imposing the whole weight of your vessel on the top of the enemy, you will either turn him over, and he will not be able to recover, or you will go right over him and send him to the bottom. There are no instances that I have known of any vessel of half the tonnage of her opponent running against the other without putting her absolutely under water; and if our vessels are strengthened enough at the bows, I have no doubt we shall succeed in dealing in that way with the enemy. As to running alongside and boarding them with those turret roofs, it would be madness. Science must perform all the duties before you come alongside to fight them, and then you will be just in fact like two men in armour, whichever happens to find the weakest point may take the adversary. With respect to the vessel which we see before us, I may state, that when I was on secret service reporting on the Channel Islands, we found that all the batteries had calculated where a ship *could come*, and they gave me a steamer to satisfy the artillery and engineer officers who were with me, where we could put a ship. We used to run the steamer, the "Alban," in, drop her anchor over the stern, and run her nose right into the sand and stick her there, and then turn round and say, "What are you going to do, Colonel?" "Oh, we can't do anything, the batteries are not built for this; there are no guns to look at you." Now, this vessel before us (pointing to a model of Captain Symonds double screw ship) would fight that battery. On her two keels she will rest upright, and fight her action. She would be another battery; and, therefore, I advocate these double keels, these flat bottomed vessels, which are perfectly capable of going into shallow water and attacking a battery, for the battery cannot sink her because she is aground. Again, there is no chance of destroying the steerage of these vessels; the rudder is in the fore part of the screw, and there is no chance of a shot getting down and injuring it. It was found in the case of the "Flora," that she could be steered steadily by the screws alone; she did not require any rudder at all. Now with respect to Captain Coles' turret. Captain Coles we will say has five guns on his upper deck, and those five guns will not be fired more than once in five minutes; probably with the power that the screw gives you, with the means of making the vessel the gun carriage, and steering to the greatest nicety, you may work your three guns on either side with the greatest ease and the greatest rapidity; when the turret guns could not be fired more than once in five minutes, you may keep up a succession of firing at every thirty seconds; therefore I consider a vessel built upon the plan proposed by Captain Symonds, with a rounded head, would have another great advantage. I dislike centre guns altogether, because I think they would blow up the deck, but with three guns on one side, and three guns on the other, with a very slight yawing, you might destroy any enemy that might be chased.

The CHAIRMAN: Has any other gentleman any remark to make upon the subject of attack? It is a very large field of enquiry. We are far from having arrived at the best form of gun. I do not think that even Captain Yonge will tell us that we have got a satisfactory land gun, much less a sea gun.

Captain YONGE: I hardly ventured to say that any particular gun or any form of rifled gun was better than any particular gun in the service. I wanted merely to point out what I thought are the advantages of a rifled gun when we have it. If it be not granted that we have it, I think the service gun is a very respectable gun indeed. I cannot agree entirely with what we have heard from Sir George Sartorius, why English ships had been beaten off by the enemy, the 18-pounder being beaten off by the 24-pounder, the 24-pounder by the 32-pounder and so on, on the supposition that the heavier gun was the more successful *owing to its larger calibre.*

In these small calibres, I fancy there is about half an inch difference in the various sizes. Thus the 24-pounder has half an inch greater calibre than the 18-pounder, and the 32 half an inch greater than the 24. I do not think that that, *per se*, is the cause of the damage, simply because of the greater *calibre*. I grant you there was greater weight, and the shot reached its destination with a greater momentum. That I concede, but what I maintain is, that that same increased momentum will now be reached, not in the yard-arm range, as in the case mentioned, but at ranges beyond 600 yards—the same momentum which is now gained by the 68-pounder at a short range. The 68-pounder is a heavy shot. It starts with a high initial velocity, but it rapidly loses it, and at a point considerably under 600 yards the velocity falls below that of the rifled shot which sustains its velocity, and ultimately delivers the shot with far greater momentum at the long range. I think it is hardly fair to take away from the rifled gun, the principal merit which it possesses. It would be as fair to challenge Tom Sayers to fight, and then ask him to tie his hands behind his back. It is not fair to take away from the rifled gun its *spécialité*, and take away from it its long range, and not only its long range, but its minute accuracy, which is the point touched upon. Whatever gunnery may be at sea, there can be no doubt as to the superiority of the rifled gun on land, and I believe the same relative superiority will be obtained at sea over the smooth-bore gun; for instance, we have very much more accuracy on land with the rifled gun. I maintain that the naval profession will be able also to have the increased accuracy at the increased range with their rifled gun, and will deliver as good a shot with it as they can now at 4, 5, or 600 yards with the smooth bore. They will certainly require a little care in its management, but to load their guns and discharge them is not merely the business of gunners. If a weapon be given them, capable of doing some considerable damage, it is only fair to ask that the ordinary and simple precautions should be taken, which will insure the due handling of the gun. Therefore, I think, the case instanced by Sir George Sartorius of the heavier shot driving off a vessel which had a lighter one will still be met, not so much by guns of larger calibre simply, but by guns, which, in addition to the advantage that calibre had in former days, and the consequent greater weight, will throw their shot with greater accuracy and, though not with a high initial velocity, with a velocity that will be maintained to the last. In the case of the carronade, they say in my branch of the profession, that it was intended solely for the navy. I know in the case of fortresses, it has been used in flanks, but the occasions are very few indeed. They are of various calibres, from 68 pounds downwards, and of various lengths. I always understood they were made with a special flash-rim, and cast in a particular way for naval purposes, that there should be no particular damage done in the waist of the ships. My impression was that a carronade was a naval gun made to enable a ship when alongside an enemy, to engage him yard-arm to yard-arm, but if the enemy did not like to encounter at close quarters, he kept at a long distance and dismantled the rigging. For my part if I were fighting a battle, and had a good gun, I would make it my business to keep the enemy as far off as possible.

Captain SELWYN: I must again beg to be allowed to rise, most emphatically to deny, because it may be important in the future course of the argument, that I ever undervalued the rifled gun. It is only those forms of rifled guns which give us long range and accuracy as their *only* valuable qualities, which I deprecate.

Sir EDWARD BELCHER: I have just one word to say with reference to carronades. At the Nile they had 68-pounder carronades on board the French "Guillaume Tell," afterwards the "Malta," she carried those 68-pounders to the end of her days, and during the siege of Gaeta we used our 68-pounders at an angle of 45, with great success, and extraordinary range, firing 18-inch shells. During the 13 weeks we used our 68-pounders, no accident occurred to them, and they threw their shells beautifully.

Commander SCOTT, R.N.: I think there have been some remarks made with respect to the rifled gun, which lead me to think the subject is very much misunderstood. The gentleman who rose before has kindly told the navy that they did not quite understand what weapon they required.

Captain YONGE, R.A.: I do not remember that I made any such remark.

Commander SCOTT: Not entirely in those words. I will say, then, on the other

side, that we have had a gun given us by the army, which is certainly not what we require for the navy; and, moreover, with respect to the very gun that has been thus introduced, we know there are great diversities of opinion, even in the army; and that at the present instant there is a committee sitting to inquire into its merits, though, in fact, the merits of the gun and its demerits have been very long since known and pointed out. It is only necessary to look at the field-pieces returned from Shorncliffe to see the effect of powder upon such delicate weapons. We have had similar guns tried in the naval service, and the vent-pieces have been blown out (which we were told arose from their not being screwed up) and accidents have happened, in which the men were dangerously wounded. Surely then, these guns are not the right weapons for us to have in naval warfare? The only time in which the gun was really used in naval warfare, was in a boat expedition at New Zealand, and on that occasion it is reported that the vent-piece blew out, wounding four or five men, killing one of them. On another occasion the face of an officer was damaged, and the whiskers of the men rather closely shaved, and in fact as a naval gunner said, "It is a wery dangerous gun." There are also specialties in connection with rifling, so as to enable us to use rifled naval guns as smooth-bores, which are very material, and which will, if examined, serve to explain why a particular kind of rifled gun may be considered good on land, and yet prove not to be good at sea. For instance, the present 110-pounder service rifled gun has a moveable breech-piece, which requires two primings —that is, the lower part of the vent-piece is first primed, and when this vent-piece is placed in the gun a tube has to be put in on its top, and thus on discharge the gun hangs fire from two ignitions, and the shot is afterwards detained until it cuts its way through the grooves in the gun. The difference between this gun and the smooth-bore is therefore somewhat similar to that between the old flint lock and the new percussion-musket, and this hanging fire is a very material disadvantage in naval warfare. Another point that has been overlooked, which perhaps ought to be more clearly shown, is that, besides the first detention, peculiar to the Armstrong, its shot, in common with all rifled shot, is further detained until it unthreads itself from the grooves. Besides this drawback, all who are conversant with rifled weapons know well, that after the first graze you cannot tell where the projectile will go; whereas a round ball, after striking the water goes straight onward and still does damage. Take, for instance, the results given by the Horsfall gun, a ball from which at 800 yards ploughed up the ground in front of the target, and then went on and smashed its edge. Nobody present could afterward doubt the smashing effect of the round ball up to 800 yards; but we are told that actions are to be fought at long distances. But can they be fought out at long distances? To see if actions can be decided at long distances, let us examine the effect produced by the rifled gun of the service upon armour-plates, and what do we find, that its shot's indentation at 200 yards is only about an inch and three quarters; but, if at 200 yards you cannot do more damage than this to an iron-clad, how are you going to decide an action at 1,000 yards? You must remember, that we are not now dependant upon sails, as we were in the olden time, so that unreeving the gear, would be a very profitless task, for it would not pay for the shot fired. Nobody disputes the value of rifled guns under special circumstances, but the question is, are we to give up that simplicity of loading and handling which we have with the round ball, and which are so essential for close quarters, for the mere attainment of longer ranges, which cannot materially influence the fate of a battle?

Captain YONGE: And accuracy, because I think in the Horsfall gun you instance it yourself.

Commander SCOTT: If you will allow me to go on, I shall be very happy to refer to that point. We all know that accuracy is part of the qualities of a rifled gun; it is common to all of them. Long range is also common to all rifled guns, great accuracy mainly depends upon the nicety of the shot's fit; for instance, Whitworth's gun, as is well-known in its early competition with Sir William Armstrong's was not nearly so accurate as it now is, because the shot have been since that trial planed, and been altogether very much better fitted. But to return to the service rifle gun; if, at the distance of 200 yards, it cannot do material damage to a plated ship, surely it will not do it at a longer range; therefore if you have armour-clad ships, this gun will produce no material effect. The real fact is that it cannot, and we had

Sir William Armstrong in this very Theatre, saying, that a 6-ton smooth-bore gun would produce about the same effect as an 8-ton rifled gun. His words were to the effect that if "you are to have a rifled gun to fire 35 lbs. of powder, the charge necessary to produce an effect upon an armour-clad, it must weigh 8 tons; whereas if it were to be a smooth bore gun, it need only be 6 tons. Bearing in mind what has been said, that you cannot carry very heavy guns in our present ships built for light pieces, and you certainly cannot use them at all in any vessel unless it is in the mid-ship part, for you would not have breadth elsewhere to fight them, the addition of the 2 tons required for each rifled gun, would be so considerable, that I believe it will be found that the use of the rifle projectile will have to be supplemental to the round ball firing. Most of those present are well aware that Mr. Whitworth in stating the reason why his gun (which was purchased for a thousand pounds, and put on board the "Stork" gunboat) split, was that the shot slipped away from the powder charge, and was fired with a space between them. Now this is a thing that will constantly occur when firing in a hurry, for the elongated shot will not be pressed close home, and when the gun is run out against the side of the ship, or the ship is rolling, a similar rifled shot—one which cannot have anything placed in front of it—will start, and the gun become damaged. I would further remark with respect to the rifled guns in the service, that some time since it was said in this Theatre that if a high initial velocity were requisite for naval weapons, the Armstrong guns could attain it by firing charges of one-fourth the weight of their shot, and that they could stand such charges. They were tried with a 110-pounder, and the gun was reduced to a wreck. This powder charge of one-fourth the weight of the shot was then tried with the shunt-gun, the shunt-shot being reduced from 146 lbs. to 98 lbs., and fired with nearly 25 lbs. of powder. That gun went also, and it was returned into store, but whether it has been repaired or not, I do not know. These results showed that the guns would not stand such high charges. In order, however, to show the value now put upon a high initial velocity, I may mention that there is a short lead-coated shot being made, which is of the same weight as the 68-pounder round ball, and that it is fired out of the Armstrong rifled gun with 16 lbs. of powder instead of the usual charge of 14 lbs. in order to attain the same velocity, and to do as much damage against a plate as the 68-pounder round ball. I think I need not say more as to the strain upon the rifled gun or its effect, or speak of the flaws which occur in the inner tubes of the rifled guns, from the great strain thrown upon them, but revert to powerful smooth-bore guns. There is an immense advantage gained by using heavy guns, as you will perceive from the contents of the table given, which is compiled upon the assumption that five 32-pounder shot fired at a plate did not effect quite so much damage as one 68-pounder.* I have taken this data from the results of actual experiments at Portsmouth, and gone on with the calculations, and shown that seven 150-pounders, fired with 40lbs. of powder each, are nearly equal to one 330-pounder fired with 80lbs. of powder at a cost of only 3*l.* 8*s.* each discharge. In the case of the seven 150-pounders, the cost is 11*l.* 10*s.*, but if the number of 68-pounders required to produce a similar effect were fired, and the men necessary to work them employed, the cost would be 490*l.*, and therefore the advantage gained by using heavy guns, both in the cost of material and number of men required to work them, is really very great indeed; and when you come to fire the heavy shot required to produce the best effect, the difficulty would be great in loading, and be very much increased with elongated shot, especially when in a hurry. In such a case, in order to secure the projectiles being forced home, you must have a round ball, and in my belief it is essential to have a large calibre of gun, and to carry such ordnance only in the midship part of our new ships. With reference to the mode, however, of working these heavy guns upon the broadside, and which is rather a question of defence, I will reserve my remarks.

The CHAIRMAN: The subject is not exhausted; perhaps it will be convenient to adjourn the meeting till to-morrow night. The subject of guns is important, and there is a great deal to be discussed besides, as, for instance, iron plates and the modes of applying them, manœuvering, &c.

The meeting was then adjourned till next evening.

* See Table, p. 31.

TABLE I.

Comparative Power and Cost of Ordnance of different Calibres.

No.	Guns.	Weight.			Cost.	No. of Men.		No.	Gun.	Weight.			Cost.	No. of Men.
		Guns.	Powder.	Shot.	Powder and Shot.					Guns.	Powder.	Shot.	Powder and Shot.	
		Tons.	lbs.	lbs.	£ s.					Tons.	lbs.	lbs.	£ s.	
5	32-prs.	14¼	50	160	2 1	65	=	1	68-pr.	4¾	16	68	0 14	17
10	68-prs.	47½	160	680	7 0	170	=	1	150-pr.	12	40	150	1 13	*16
7	150-prs.	84	280	1050	11 10	112	=	1	330-pr.	26	80	330	3 8	*16
350	68-prs.	1662½	5600	11200	490 0	5950	=	5	330-pr.	130	400	1650	17 0	*80
20	68-prs.	95	320	1360	14 0	340	=	"Warrior's" Broadside.						

17½ "Warrior's" Broadsides = Broadside of Scott's Fortified Vessel.

* Number of men to work these guns in the manner proposed by Commander Scott.

Tuesday Evening, February 17th, 1863.

Captain E. GARDINER FISHBOURNE, R.N., in the Chair.

Adjourned Discussion on Captain Selwyn's Paper.

The following letters were read:—

"Union Club, February 17th, 1863.

"SIR,

"I am afraid my expressions last night were misunderstood. The subject being —Attack and Defence as applied to our Armoured Vessels—I mentioned that like men in armour, the victory would remain to science, to finding out the weak part of an adversary.

"If we use the word '*impregnable*,' the vessels will not be injured, and the result of the action must depend on decided manœuvre, the weaker vessel succumbing to velocity or subject to impingement by the vessel more adroitly handled taking her at such a disadvantage.

"But on the question of broadside weight of shot. I should like much to know what difference would result as to the weight delivered, acting to cause the plates to curve and fly off, between the old 68-pounder carronade and the new 68-pounder long gun at 200 yards.

"I regret much an engagement prevents my being present this evening.

"Yours truly,

"EDWARD BELCHER.

"As to any vessel yielding during action from any punishment inflicted by her adversary, I do not think the danger (to an iron-clad) would be so immediately felt as to warrant immediate submission."

"17th February.

"MY DEAR CAPTAIN FISHBOURNE,

"I came up expressly to attend Captain Selwyn's able and important lecture—important because it brings forward all the salient points upon which naval warfare must be conducted. I regret very much that circumstances will prevent me from taking part in the further discussions on those points to-night. But perhaps you will be kind enough to read the following observations which I intended to have made, had I been able to take part in them.

"I venture to give opinions founded upon the experience of 72 years, and of a man who has felt a deep interest in matters connected with the good of our country, and more immediately of my own profession. The limits of a letter do not admit of entering into arguments to establish my views, therefore these my opinions must be taken for whatever they are worth.

"I believe, that, as we are as far as ever from knowing what will be the future forms and materials which our vessels-of-war are to assume, nor of the developement artillery is susceptible of, we have no safe data for forming correct notions upon 'Attack and Defence in Naval Warfare' in the future.

"I believe that the thickness of armour-plating and backing already pierced, has passed the limits that *sea-going* vessels *can* support for practical purposes.

"I believe that no naval port can ever be blockaded, nor large fleets of armour-plated ships cruise about as of old.

"I believe that we shall have to return to wooden ships rendered *un*inflammable, but of peculiar forms, and constructions for carrying heavy artillery of the largest calibre.

"I believe that the mode of naval warfare used by the most intelligent and warlike nations of antiquity, of sinking by concussion from force and velocity given by oars, will again be used, as one of the most efficient modes of attack, by means of steam power, an infinitely more manageable and more powerful agent than the oar was to the ancients, and that the combination of the ram and the battery, will only increase the value of each other without any deterioriation to either.

"I believe that the smashing large holes at a thousand yards by guns of very heavy calibre, is far more important in deciding naval battles than by neat gimlet-holes of small diameter or by hitting occasionally at even four thousand yards.

"I have much more to say on naval warfare in combination with the sister-profession, but I cannot venture upon such interesting grounds now. I hope, however, that as public attention is at last awakened to the immense importance of a subject of such a vital nature to our country, that both professions will unite in a kind and zealous spirit to work out the problem we have touched upon. The military and naval art of war have (and in a naval and commercial empire), must have much in common. A moiety of our army are already half sailors, and therefore can understand and appreciate the soundness or weakness of a sailor's reasoning,—a kindly spirit is all that is required to come to just conclusions.

"Believe me, my dear Capt. Fishbourne,

"Yours very faithfully,

"G. R. SARTORIUS."

The CHAIRMAN: We will take up our discussion where we left off last evening on the subject of attack. After that, in the order of the paper, the question of defence.

Captain HARRISON, R.A. Secretary Iron Plate Committee: There are a few points which, with your permission, I should like to remark on, regarding attack. I feel a certain amount of diffidence in speaking upon this subject, which, in a great degree, relates to naval matters; but what Sir George Sartorius has said in his letter about army and navy men meeting half way, bridges over that difficulty to a certain extent. From the paper Captain Selwyn was good enough to read last night, and which was a source of great interest to us all I am sure, I gather that he, as a naval officer, is far from satisfied with our present rifled Armstrong gun, or with the other gun which is opposed to it to a certain extent, namely, the Whitworth gun. If this opinion was altogether agreed to by naval officers generally, of course as an outsider —as a military man, or civilian, we must all bow to it, and nobody would be bold enough to dispute it; but I can say that within the last six weeks, a naval officer who has just returned to England, having paid off a line-of-battle ship, in conversation with myself spoke about this 110-pounder Armstrong gun which had been served out to his ship; and he told me that at the time these guns were received by him, he was not at all in favour of them—that he had heard of numerous difficulties about them, of which we have heard repeatedly—and that he was quite prepared to find that it was anything but a serviceable or good gun. To test this, he made every possible trial that he could, meeting all the different points—the difficulties of loading—the drawbacks of the vent-pieces, the difficulties of quick firing—the assertion that his crew would be suffocated by the smoke, and so on. He told me, that without exception, he, his officers, and his crew found that the gun was an excellent one. Those were the terms in which he, as officer in command of a line-of-battle ship, spoke of this gun. This is not a solitary opinion; I have heard the same from many other naval officers. Therefore, I say, that if this gun is not condemned generally by the navy as a naval gun, it seems to me that that gets rid of a part of the difficulty.

I should like to take one or two of the points that are urged against this gun. First, what we were told last night about this gun in comparison with a 68-pounder. I allude to the damaging effect against iron plates. We have been told repeatedly, both by accounts in newspapers and otherwise, that the 68-pounder is the gun to have, at short ranges, that the 68-pounder smashes your plates, and does damage

which the 110-pounder is quite unable to do. Now, what is the state of the case? That, in November when experiments were made at Shoeburyness, putting the 110-pounder Armstrong gun and the 68-pounder on an equality, the 110-pounder gun fired with a 16lb. charge and a short shot of 68lbs. weight, your 81cwt. gun beat your 95cwt. gun. The damage in absolute indent, alluding to what Commander Scott told us last night, taking the ordinary damage of the 110-pounder at a 1½ inch, in this case was 2 inches and 7-10ths. Not only that, but the general damage was larger than the general damage of the 68-pounder. Therefore, I say, that your 81cwt. gun for a short range has been proved to be at any rate equal to your 68-pounder in damaging effect. I think at a long range there is no dispute. One always hears that for long ranges, when you require it, your rifled gun is a better gun than your 68-pounder. Therefore those are two points which may be established.

Well, take one point farther, which may be a material one, or it may not. Captain Selwyn last night did not seem to think in the present state of the case very much of it. I allude to the *pretty round holes*, which he spoke of as being bored in the side of these ships. Be that as it may, we have at any rate proved that you can bore these *pretty round holes*, which is something, considering that before last September we were told that these armour-plated ships were absolutely invulnerable to solid shot. Now, I say, we have arrived at a point where we show that these armour-plated ships can be bored with *pretty round holes* at 800 yards. Very well then, one step farther. The 110-pounder will do this, for it has blown a hole through the "Warrior" target's side at 200 yards, with a charge of powder of 20lbs., and a shell weighing 80lbs. There are, therefore, three things that the 110-pounder will do. It will damage an armour-plated ship as much—not to say more—at 200 yards as your 95cwt. 68-pounder; it will, I think, without dispute, do more damage at a long range; and it will also bore a *pretty round hole* in the side of your ship at 200 yards.

I would now make one remark about two other points which were urged against this gun—one regarding the vent-piece difficulty; and the second, the difficulty, which I must honestly admit is of more consequence—the difficulty about the working of this gun. First, about the vent-piece. We were told last night a very doleful anecdote of the injury which had occurred to certain sailors owing to one of these vent-pieces being blown out, by which one was injured in the eye, and another had his whiskers singed, and so on. It seems to me that this tells much more against ourselves as professional men than against the gun, because it is perfectly well-known that if the gun is used as it ought to be used, namely, with proper attention paid to points of drill, the vent-piece cannot be blown out. I speak with the greatest confidence on this subject, because I had the good fortune to take part with the first battery of Armstrong guns that was ever used in the field. We found that two vent-pieces were blown out, but from that time, when the officers were compelled to enforce the orders of the drill which are laid down for this gun, not a single vent-piece was blown out. Therefore, I say, that seems to me much more an argument against ourselves as professional men than against the gun. One might as well argue against the old smooth-bore gun because, as we know, it sometimes happened that a man's arm was taken off through the vent not being properly served. One might as well bring up that argument against the gun. It was not the fault of the gun that the man's arm was blown off. It was because the drill was not properly carried out in serving the vent. Regarding what I said before about the working of this gun, I certainly do think that that is perhaps a greater difficulty; but it seems to me—I speak with all due deference to the naval officers present, who are naturally better judges on this point than I am myself—but it does seem to me that this ought not to apply as much to the navy as it does to ourselves, for this reason—that in forts, where this gun would have to be used—in large places like Gibraltar, Malta, Portsmouth, and Plymouth, where it is well-known you might only have one gunner to a gun, you would have mainly to depend for the handling of your gun on lines-men, or militia, or possibly even on volunteers. It would, therefore, be of the greatest possible consequence that you should have some gun that there would be no difficulty about; but in the navy surely that would not apply. In the navy you have your gun detachment; every man must know his gun

as well as possible, and his drill. Therefore, I cannot see how that argument can possibly apply. To return once more to the vent-piece. There is one more difficulty about the vent-pieces, which is, that they are not able to stand high charges, and break. That certainly at the present moment is against the gun, but I see no reason why we should not be able to overcome that, either, by what I have been informed is, to all appearance, a very good arrangement, namely, Mr. Westley Richards' improvement on Sir William Armstrong's breech, which I hear most highly spoken of by people who are competent to judge; or by another arrangement which is the new process of tempering steel, which I have been assured by Mr. Anderson and others who have seen the process, gives the greatest possible strength to the vent-piece.

Another point which I think is very material in the attack on these armour-plated ships—in fact, I think only second in importance to the gun—is the projectiles. There is no doubt that the cast-iron projectiles which have hitherto been used, have been of the rottenest possible sort. They were all very well and very good for cheap projectiles, as long as you were not opposed to a superior metal like wrought iron. It is an undoubted fact that at the present moment they are perfectly useless. We have lately seen at Shoeburyness the great advantage of taking a little trouble in the manufacture of cast iron and improving it at very small cost, and thereby getting almost as good an effect out of it as out of wrought-iron. I certainly do think that this, next to deciding on the gun, is a very important subject to be considered. I also wish to say one word—and, by the by, I shall remark at the same time, that I am not an Armstrongite or a Whitworthite, or disciple of any other of the numerous gentlemen who have given their attention to the subject of guns of late years; and I make this remark because it is very much the fashion, if one feels called upon to make any remark in favour of a gun, at once to be stamped as a disciple of that rifle system. I beg most distinctly to say, that I am neither the one nor the other. My sole wish and anxiety is to see the best possible rifled gun, both for ourselves and the navy, that can be found; but I do think the case against the Armstrong gun at the present moment is by no means as strong as we were led to suppose. I do not think we have got the worst rifled gun that can be had; in fact my own feeling is that we have got by no means a bad one. Before I sit down I should like to say one word about what was also alluded to by Captain Selwyn, in his paper last night, about those *pretty round holes* that were bored in the side of the ship. It seems to me that Mr. Whitworth has hardly received credit, certainly from Captain Selwyn in his paper, for what he has done, for this reason—it is an undoubted fact, that up to the time of Mr. Whitworth's experiment, those ships were considered invulnerable. We all know—and no doubt many of those present have read—a pamphlet which was written by Mr. Scott Russell some time ago, in which he brought prominently forward a fact, which was very well known before, that occurred in the Crimea in one of our own ships, where a part of the crew were absolutely driven out of that ship by shell fire. Therefore it was a very great thing for the country to be able to say, "We have got invulnerable ships; they are not only invulnerable to shell but they are invulnerable to shot." Indeed that was a great thing to be able to say. Mr. Whitworth came forward, and said, "You have got nothing of the sort; I can not only penetrate your ships by shot, but I will penetrate them by shell." To prove this, he got the consent of the Admiralty to construct a small box, and I can assure all those I see around me at the present moment, that on this box arriving at Shoeburyness for the experiment to be carried on, it was received with considerable merriment by all those present, they not knowing what was to be done with it. On the day of the experiment, with a very large meeting of officers of the navy, and officers of the army, and civilians present, I think I can safely say that nobody except Mr. Whitworth and those belonging to the ordnance manufactory at Manchester, believed for one moment that he would do what he said. In fact, I am sure he might have made a great deal of money if he had chosen to take up the bets that were offered him that he would not penetrate this box by a 70-pounder shell. He did it in face of all, and blew the box down. I say I consider that a great triumph. More than that, Mr. Whitworth said, "I will penetrate your 'Warrior,' or the best ship you can put up; if you put a 5-inch plate on your 'Warrior' I will penetrate that, and penetrate it at a thousand yards." This was very little more believed than his previous assertion, but it was tested—not at a thousand yards, because that range

was not available, but it was tested at 800 yards, with a result similar to what occurred in the previous case. Now, when one speaks of a shell, you expect to a great extent, the effect of the old cast-iron shell. There is no doubt that Mr. Whitworth has not arrived at that, but it has a very different effect. He has only up to the present time succeeded in blowing a hole through the skin of the ship; but still, in my humble opinion, I say that it is a great step in advance, and I see no earthly reason why, when you get heavier guns of larger bore, capable of firing larger charges, and which will give you a shell holding larger bursting charges—I see no earthly reason why Mr. Whitworth should not follow up what he has already done—put his shell through the skin of the ship and then explode it. I say if he does that, it will be a very great triumph. I consider that what he has already done is a great triumph, although there is this proviso, that certainly the expense of his projectiles at the present moment is a serious drawback to the use of them; but there is no reason, if the minds of the manufacturers are once called to this point, and they are told, "We require a particular manufacture of steel to do so and so, particularly tempered and particularly hardened," why we should not find exactly what has been found in the instance of the armour plates, which in the course of three years have become as different from one another as chalk from cheese. Three years ago they were useless, and now Mr. John Browne's armour-plates are very nearly A 1. I say, I see no reason why, in the course of a short time, we should not get just as great an improvement of these steel projectiles at a moderate cost, as we have already got in armour-plates.

The CHAIRMAN: Will you kindly say what description of shot was fired on the occasion? Were they the cast iron 68-pounder shot?

Captain HARRISON: Do you mean on the trial of the 68-pounder and the 110-pounder?

The CHAIRMAN: Yes.

Captain HARRISON: Both cast iron.

Commander SCOTT, R.N.: May I ask one question of Captain Harrison? Do I understand you to say that there have been no vent-pieces blown out since the affair in China when two were blown out?

Captain HARRISON: Oh, dear, no! I was talking about what happened in my own battery in China.

Commander SCOTT: Because under the most careful officers at Shoeburyness—you are aware, of course, that I cannot mention names—but, under the most careful officers, vent-pieces have been blown out, and it is not so very long ago that one went up in the air and came down not very far from the commandant.

Captain HARRISON: I am not aware of that; I do not doubt it. I was merely alluding to the difference we found as soon as we enforced the order of drill—that the vent-piece should be dropped in and not held. Instead of dropping it in, the men held it and screwed up the breech-piece. The result was the vent-piece was not down, and out it went. It was no fault of the gun, but the men did not do what they were told.

The CHAIRMAN: Will you allow me to ask one question. Are you aware of the difference of charges? Of course you can fire an Armstrong gun with a small charge, and no accident then will happen to the vent-piece. Are you aware that the charges that you were using in China were very much less than the charges that have been recently used?

Captain HARRISON: They were using precisely the same.

The CHAIRMAN: Your fact may be a fact, and also Commander Scott's may be a fact.

Captain HARRISON: They were both field guns. We were using the same.

The CHAIRMAN: Is there no alteration in the charges?

Commander SCOTT: I was alluding to this. I think it would give a wrong impression to those who really do not know the facts, if it is not understood, that it is by no means certain that the Armstrong gun will stand that charge of 20lbs. of powder. In fact we have every reason to think that the Armstrong gun will not stand it, because the Armstrong gun is being continually destroyed with the service charge. There was an officer commanding a line of battle ship who was sitting here last night, who could have mentioned a gun that was destroyed under twenty rounds. It is not a solitary case.

Captain HARRISON: 20lbs. of powder would not be required. 18lbs. of powder with an 80-pound steel shot, is all you require. It will penetrate the "Warrior" at any time.

Commander SCOTT: Has that actually been done?

Capt. HARRISON: Actually done at Shoeburyness.

Commander SCOTT: From an Armstrong 110-pounder?

Captain HARRISON: Out of an Armstrong 110-pounder, by a shell at 200 yards range.

Commander SCOTT: I did not know that it had been done with a shell; but that, you are aware, is considerably beyond the ordinary charge of the Armstrong gun.

Captain HARRISON: Considerably.

Commander SCOTT: And we do not know what will be the effect on the gun of driving those hardened shot through it at those high velocities.

Captain HARRISON: I was merely talking about what had actually been done.

Commander SCOTT: But don't you think it would tend to give a wrong impression if the case is only an exceptional one. We may do great things by exceptional charges, but still the gun will not long stand even the ordinary charges.

The CHAIRMAN: Captain Selwyn will now perhaps answer some observations that have been made.

Captain SELWYN: I think, if the meeting will allow me, I will go back a little to what took place yesterday, as I have to answer certain observations which were made then, on subjects which have not come before the meeting this evening. I was happy to find that my opinions received confirmation in several instances from officers high in my own profession; and as Captain Yonge addressed his observations, and made his objections to points which I did not assert, his observations require no answer from me.

The first question was, that of the motive power and its application; now, with regard to evaporation, I must remark that Mr. Newenham assumes that evaporation is a fixed point. I think if we went back a few years in the history of steam, we should find that it has been at no time a fixed point, that as we improved our boilers, as we improved our method of firing, so we improved in the quantity of duty obtainable from a given quantity of coal. It would be very unsafe indeed, to assume that we have arrived at the *ne plus ultra* on that head. Therefore, evaporation can scarcely be considered as a fixed point; and if the system which I had the pleasure of bringing to the notice of the meeting be a true one, then evaporation—that is to say, the duty done by certain quantities of fuel—may be, and probably will be, enormously increased. To show how necessary that change is, I may instance the case of a trial which was made by Mr. MacConnell, whose name will be known as the late locomotive superintendent of the London and North Western Railway, in which he divided a locomotive boiler into four portions (and I think this is peculiarly interesting to naval men) by the addition of what might be called extra tube-plates. The result of firing in that boiler, and raising the steam in it to the ordinary pressure, was that the water in the compartment nearest the funnel did not boil when the full steam was obtained from the boiler; the water in the second compartment did boil, but gave off very little steam. The two compartments nearest the fire-box did the whole of the duty, or very nearly the whole of the duty. On that result he has since expressed to me his opinion, that in all future locomotive fire-boxes, it will be prudent to continue them forward into the shell of the boiler, leaving only a very small portion as the length of the tube. That applies more especially to marine boilers, where hitherto our furnaces have been compressed in size, and the stoking thereby rendered very difficult, simply because we gave too much value to the tube surface.

With regard to the letter which has been read from Admiral Sartorius this evening, the gallant Admiral says, that we have no safe data on which to proceed in our considerations of the subject of the paper which I had the honour to read. With all due deference and respect to his elevated rank and his years, I must dissent in a measure from that opinion, for if we considered that at any given point in our argument, because we had not *all* the *data* necessary, therefore, we had *no* safe data, and we are to come to no conclusion, we might put off all our conclusions on matters of science, *ad*

Græcas calendas. Captain Harrison has done me the honour to make some remarks on what I said. I think if in the discussion we were to confine ourselves more to mathematical laws and less to the little experiments which seem to vary—sometimes with the strength of the powder, sometimes with the quantity, sometimes with the hardness of the shot, sometimes with the effect sought to be produced, which certainly then does not produce other effects than those sought—we should arrive at a much more satisfactory conclusion—if we confined ourselves more to mathematical demonstration, than if we entirely relied upon that practice which, though one ounce of it is better than a pound of theory, is utterly useless unallied with that theory.

The case of the 68-pounder as against the Armstrong gun, or the other forms of rifled gun now in vogue, is this—not at all that we disavow or disapprove a rifled gun; we seek a rifled gun; but we seek, first and above all, the gun which, having a spherical shot, gives us a high initial velocity; a gun against which no demonstration can possibly prevail to convince any mathematical mind, that the effect will not be greater, and the initial velocity greater, given the same nature and the same weight of shot within certain distances—up to those distances at which the smaller shot begins to assert its superiority of range, because it is less resisted by the air. We value, then, first of all, that projectile, which, having a spherical shape, has the greatest contents, as stated in my paper. It gives us an efficient shell; and while on this point I will take leave, if the meeting will allow me, to read some results in to-day's *Times*, of the fight between the "Alabama" and the "Hatteras." We find that the "Alabama" fired all shells (except from 32's) with percussion fuses for the rifled, and concussion fuses for the smooth-bore projectile. She had principally smooth-bore guns on board—a 100-pounder rifled gun, one 68-pounder smooth-bore, six 32's smooth-bore, one James's rifled field-piece, which she obtained from the United States steamer "Ariel." Many of the shells passed through both sides of the "Hatteras" without bursting, in consequence of the close quarters at which the action took place." That remarkably confirms what was said here last night in ignorance of this paragraph—that actions will never be decided at long range. They may be fought during certain times at long range, but they will never be decided. "The 68-pounder pivot-gun in charge of an Englishman, who had served his time in the Royal Navy, and passed in gunnery on board the 'Excellent,' fired under his direction, seven shells during the engagement, and with wonderful precision, every shot hitting about the water line. The 'Alabama' was struck on the starboard side of the stern-post, immediately above the screw, by apparently a 32-pounder shot, and three 12-pounder shot on the same side amidships. But the 'Hatteras' was struck by a shell on the port bow causing a splintered aperture, and by a 32-pounder projectile through the funnel and one of the boats, the splinter from the former having caused the only casualty they suffered." You will remark that in this case the principal damage was done by the 68-pounder shell, a large spherical shell, and that that occurred near the water line. Now, I must say that it is an utter mistake to suppose, because you have armour ships carrying that armour seven feet below the water line, that in any naval engagement, you can secure for a single instant, even in the calmest weather, that your undefended bottom shall not be exposed to the attack of shell. Armour is nothing more, applied in that way, than a partial protection against shot, and no protection at all against rams. In my paper I spoke of a gun which should combine the rifled projectile with the great advantages to be derived from the smooth-bore at close quarters, and which we value most in the navy, it having been our habit always to fight when we could at close quarters, and we hope to be able to do the same thing again. The "Alabama" has been able to do it. We have a gun which does combine all these advantages offered to us, with a rifled projectile which can be fired at long ranges when we require such a shot, and with quite sufficient accuracy for all naval purposes. When you take into consideration that the error from the means employed for judging distances becomes greater in proportion as that distance increases, and when you take into consideration the movable nature of the platform from which the gun is fired—when you consider that these two causes come into operation far more than any difference in the accuracy of guns can do—you will see that we have reason to be satisfied with what is offered to us as a naval gun by

Commander Scott, strengthened when we required to fire at long ranges with solid shot, by the system of Captain Blakeley. I do not fear to say it, although I have listened with great pleasure to the opinion of the naval officer quoted by Captain Harrison, that the majority of my profession are firmly of opinion that the 68-pounder, properly treated, made of proper metal in the way that it may be made, will be a cheaper, and more efficient, and more lasting gun, for every purpose which a naval man can require, than any of the exquisite mechanical weapons which Mr. Whitworth and Sir William Armstrong have offered to us.

With regard to the experiments tried by the officer who probably had an Armstrong gun on his quarter-deck or on his forecastle, although approving of that gun in that place, I did not hear that he undervalued by any means the guns with which I presume he was armed below—the 68-pounders, on which, I cannot too often repeat, we must depend for our work at close quarters by means of concentrated broadsides. If any one tells me that the blow of a broadside of these 68-pounder shots—hardened as they may be—they may be made of any metal—they are not limited in that respect—will not produce a greater effect than one or two holes in the plate, I doubt his conclusion; the effect produced by penetration being a totally different one from that produced by concussion. If I wish to destroy a plate of iron of whatever thickness, I do not seek to penetrate it with a *small point*, nor even with a *number of small points*. If that were the case, then rivet holes might destroy all iron plates. They simply destroy them in proportion to the amount of strength they abstract at the time, but they do not break up and destroy the fibrous nature of that iron plate. They do not leave it, as was done by the six guns fired in a salvo, in such a state that no one dared to fire another gun at the plate for fear it should drop off. I need not say that if that plate be knocked off—if a single plate be knocked off, and the second broadside be loaded with shell and fired at anything like the same spot, which is quite possible at short range, the effect produced on that ship would be infinitely greater than if each gun of that broadside had been a Whitworth and penetrated the plates, even granting that these plates had been penetrated by shell at that short distance, and that the shell had exploded with the very small capacity which a Whitworth shell must necessarily have. There is another paragraph which bears on that subject in the letter in *The Times*, to day. It speaks of the value which the Confederate army attach to the Whitworth gun as a field-gun, and it says that its accuracy and long range are most valuable; but it also shows what is an important fact, that the only thing to be sought, and what they regret very much the absence of, is an efficient shell for the same gun. I need scarcely point out to a military man that if a square of infantry, or a squadron of cavalry, is to be smashed up, shrapnel and case are far more efficient weapons from smooth-bores, than any amount of Armstrong guns. I do remember, and I think most of the members of this Institution will remember, that certain Armstrong guns in China—I do not know whether Captain Harrison commanded that battery—were withdrawn to make room for howitzers, when the opposing force was within the very menacing distance of 300 yards.

Captain HARRISON: No, I did not command it.

The CHAIRMAN: It was so at Magenta.

Captain SELWYN: It may be a fallacious statement; it was one which was publicly made, and I have yet to learn that it has been as publicly confuted.

Captain HARRISON: It was not certainly withdrawn at any time to make way for any other. They were too glad to get it.

Commander SCOTT: I have stated, and the statement was this, that the Creek battery continued firing, and the Armstrong guns could not silence it, but Desborough's battery silenced the Creek battery in a very short time. That was stated in *The Times*, and I think I asked Captain Desborough if it was correct. I said point-blank—"Is it so, or is it not?" and he admitted it. There were several officers of artillery present.

Captain HARRISON: That must have been another battery; it was not our battery.

Commander SCOTT: If it had been disputed at the time I should have read it to you out of the blue-book that was published by the Ordnance Committee, and as it is quoted, I think it is well to mention again, if I may be permitted to do so, because it is really important, that the only critical time in the whole of that Chinese expedition, was when our army was under the principal Taku fort, when they marched up

against it, and found that it was not breached, that the breach was impregnable in the strongest part; the men had to lie down on the berm, and the only guns brought up at that time were smooth-bores, which, pounding away at eighty yards, made a breach. I think that speaks rather strongly in favour of the smooth-bore gun.

Captain SELWYN: I have adverted to these points, and to the use of shrapnel against infantry as opposed to that of the rifled shot. As an illustration, I have brought forward a circumstance which may or may not have occurred; it is open, apparently, to doubt under what circumstances, or how it occurred. We take, of course, the best information in our power to collect, and we construct our arguments upon that information. That may be a mistake, but there can be no mistake in the mathematical law that the sphere will contain a greater quantity of the said shrapnel than any rifled projectile that you could possibly produce of the same weight. There can be no doubt that the sphere is the greatest containing body, and that by no possibility can you put the same weight into the form of a cylinder, or any elongation, without, at the same time, reducing its possible contents. Again, it is perfectly impossible to burst this shell, the segment-shell, (I think we have one here) with the same effects as the shrapnel. Shrapnel is an invention which everybody who has used it, has admired, and which I, for one, would be most unwilling to see absent from the guns of the navy. It is perfectly well known that it sends its whole charge of bullets forward. The segment-shell does not do so; the segment-shell sends almost as many pieces in a circle round it in rear as well as in front; it does not, therefore produce the same telling effect against infantry; it does not produce the same telling effect against men exposed in any way; therefore I should be unwilling to lose the shrapnel. Again, there is another most important consideration. We have not banished wood from our vessels; against molten iron we have no defence; if a shell carrying molten iron ever be projected at us, and it pierce any portion, it will inevitably set the ship on fire. Now the 68-pound shell will carry molten iron; rifled projectiles, more notably those with lead about them, will not. That, therefore, is another point which induces us to say what we do say in favour of the 68-pounder as a naval gun, rifled if you will, by all means, but do not take away from us any of the advantage we have, to give us some for which we thank you very much, but which we do not want, to the exclusion of others. I have said that hardened shot may be used. I should like to understand *thoroughly* how far charges of powder are to be increased to produce effect, and then to be claimed as the daily work of the gun. True, the 120-pounder did do the work on that occasion specified. Could it stand doing the work for ever, or for any length of time, as the 68-pounder would stand doing its work? Then again, we are congratulated on having, I suppose, comparatively impregnable ships. Well now, I take leave to doubt whether we can ever call ships impregnable in the first place; in the second place, whether they are not notably pregnable when, as I say, a salvo of six guns only can be fired out of sixteen which will compose the broadside of a frigate, and so damage the armour-plate that you really expect to see it drop into the sea—a very undesirable thing, but not unlikely to occur. Another thing mentioned was that this improvement of shot was to go forward until we could get such effects, as we have not got yet, but I think, hardly so. Captain Harrison will pardon me for saying it. But that is only one side of the question. It is only reasonable to suppose that as armour-plates have improved, so they will continue to improve, and that if the shot continue to be improved, so the armour-plates may continue to be improved in the same ratio; consequently it is a moot question whether we shall absolutely get the wonderful effects that are promised for the future—at least they are not to be assumed as absolutely certain by any means. That this 68-pounder gun, of which we speak as producing such effects in naval warfare, has cheapness and an immunity from damage by the ordinary accidents at sea, such as the rifled gun does not present to us, is positively and absolutely certain. I can throw that, if my vessel gets ashore, overboard with a buoy. I need not even, if I do not choose to do it, and have not time to do it, and that is sometimes the case under such circumstances; I need not even grease the tompion and put it in the muzzle and stop up the vent. We generally take those precautions, but it is not absolutely necessary that it should be done; that gun may stay at the bottom of the sea until aid arrives, perhaps three weeks, perhaps a month, perhaps six weeks, to get that ship off, and if she is so got off, her guns will be recovered quite as valuable as

they were before. Now I utterly deny that under those circumstances an Armstrong or a Whitworth could resist the action of the sea in the same way. That, therefore, is a most valuable point, which, I think, artillerymen do not sufficiently consider, as they are not in the habit of throwing their guns overboard. They perhaps may find occasion to leave them in a ditch sometimes, and to allow them to be knocked about a little by various capsizes, in going quickly across country, and even then I think they will find that the old brass gun has its advantages after all. The only other point which requires notice from me is, the indisposition which seems to exist generally to give naval men credit for knowing their own minds. Now, whatever may be said of the sex which we agree to admire and which sailors are supposed especially to admire from their few opportunities of seeing the fair members of that sex, I beg leave to say that sailors have not been so generally reproached in history for not knowing their own minds, that they not only know exactly what they want to do, but they know how to do it, and it is not fair to tell me that I do not know what I want. Pardon me; you tell me that you know better than I do. That is the question—not that I do not know and do not tell you, but that you know better than I do about what I want, and if that be the case, then you have more experience of what is wanted at sea, and you have gained it without that service and time which most, if not all of us, have given to the question. It may be so, but we are accustomed to view it with grave distrust when stated of other professions. Notably that is the case in considering the question of guns. We have seen, in opposition to all that could be said in this Institution, four and a half millions of money spent on a gun which, if it were the wonderful weapon which it is said to be, would not, I think, have so many alterations, so many failing breech-pieces withdrawn, a large heap of which are somewhere to be found in the arsenal at Woolwich, so many shunts and changes generally. Again, Mr. Whitworth, as I pointed out here, began with a thing for which he was evidently the very best man to go to—mechanical fit. No one could accomplish a mechanical fit like Mr. Whitworth, and everybody knew it; therefore, as long as he stuck to the mechanical fit, there was no possible doubt we should get an excellent gun made in an excellent way; but, unfortunately, he found that the said mechanical fit was liable to most serious objections. I need not deal with those objections, because he has acknowledged that they existed, by reducing, by taking away the mechanical fit, by making it no longer a fit, by altering the hexagon, which happens to be the very form best calculated for turning in a bore with a projectile force behind it; he found that the hexagon turned in the gun, and then probably finding, as I think my friend Captain Fishbourne mentioned, the same effect as in the Russian trials of the Whitworth—where they began with six sides to the hexagon, and ended with twelve—*i.e.*, a dodecagon.

The CHAIRMAN: After twenty-five rounds only.

Captain SELWYN: Mr. Whitworth has acknowledged this by taking away small pieces at the points, where the bearing comes, and allowing the shot to take a fresh bearing on a curved surface, but this is not a gun which can possibly last; increase the weight of the shot, and you of course relatively increase the force on the bearing surfaces, inevitably so, therefore, the larger gun will be ruined sooner than the smaller, which we might expect. The 6-pounder will probably last for a great length of time in comparison with the 100-pounder or the 120-pounder; but inevitably the mechanical principle just spoken of cannot be right; it requires such delicate little shavings and turnings after a mechanical fit has been made; it requires to have introduced into it what I call transcendental curves instead of bearing surfaces. This is as near an illustration as we could get of the new bore (pointing), but I have no doubt it has been altered since, because it is altering daily, and if the gun has been fired out of, it is sure to be altered, for it is not in the same state after it has been fired out of a dozen times, as the Russians have found. Therefore I mean to say that we have a lesson here, that to men who are to use your weapons, you had better go to prove them, not to men who exceptionally, and late in life, have taken up the subject, and applied to it, not the knowledge which bore on that subject especially, but knowledge which they acquired in their own profession, and applied by, sometimes, a forced construction to the subject, to which they were turning their minds. We have seen that with regard to Sir William Armstrong's shot, compounded with lead; it is notably the case, that you have got a shot which cannot

resist unhurt the throwing down into a shot-locker, or the galvanic action sure to take place in the said shot-locker. You may keep a certain number of those shot on deck, you may take the greatest care of them and grease them, but if people will only go to sea they will see the shot, and the men, and everything else under water for weeks together at a time. You could not possibly engage in the operation of cleaning every shot in a line-of-battle ship once a week; your men would be engaged with nothing else. If you threw them down into the shot-locker, if you move them up on deck and throw them down carelessly, they are injured in such a way that they very likely will not fit the guns. The same observation applies to the accurately turned shot, such as Whitworth's. The angles do not admit of that kind of handling, which from seamen's hands they are absolutely sure to receive in the hurry of action, if at no other time. It is for these reasons,—and I am anxious that there should be no mistake, that we naval men have made up our minds, that we do not blow the trumpet with an uncertain sound. It may be true that gentlemen have, on certain points expressed their approval of the weapon—the Armstrong gun, or any gun with great precision at long range—but if you ask them whether they set any value at all upon the other things, whether they would consent to banish from their decks the whole of their spherical shot guns, and take nothing but those, they would say: "Pardon me, no, we must have a gun which can do its duty at short range, first, the high initial velocity first, and great contents first; then if you will kindly give us a large measure of accuracy with long range, we shall be delighted to take it; but even for these advantages we will not sacrifice what I have called in the paper 'the rough and ready character of the weapon.'" I am afraid I have detained you longer than I should have done, but I can only explain by saying, that many men much more able to treat the subject than myself, have not been able to attend here this evening, and, therefore, I have done my best to say what was to be said, on behalf of my professional brethren.

Captain BURGESS: May I ask Captain Selwyn a question? Does Mr. Whitworth use wadding with his guns in case of having to depress them at sea?

Captain Selwyn: I think, as far as I have been able to understand, that is not the case; here is a model of a naval gun which is mounted on a long slide, but which, of course, on a broadside, would not be mounted on such a slide, but would be run out at a port; when the ship is heeling over 2 or 3 or 4 degrees, or even rolling without heeling over, those guns on the lee broadside in the process of running out, are, and always will be by seamen, run out with great velocity. They like to see their gun going quick, and do not care a farthing what breaks down, as long as they get the gun out. That gun runs up against the side, and in doing so it communicates the force to the shot. The *vis inertiæ* of the gun being suddenly brought into play, it is almost sure, if the gun be at all depressed, to send the shot out into the sea, or leave an air space, and this effect is still more likely to happen with a shot without a wad. That would be the evil ordinarily of not using a wad. That wad I fancy, as far as I can understand the subject, cannot be used for the reason of the peculiar shape of the shot, it would probably result in jambing the shot in the bore, and, therefore, burst the gun.

The CHAIRMAN: Captain Yonge introduced many things which really had nothing to do with the paper, and which were quite foreign to the argument, and he assumed positions which were not assumed by the writer of the paper. Thus he assumed that greater accuracy was admitted in the Armstrong gun, and, therefore, that it was preferable. But that is all assumed; such is not admitted. Now an indispensable quality, and a prime quality of accuracy at sea, and everywhere where distances are unknown, is a high initial velocity. That was one of the things that Captain Yonge especially made little of. Yet since the importance of high initial velocity has been shown by lectures in this Institution, its value has been admitted at Woolwich, and the result has been that both Mr. Whitworth and Sir William Armstrong have shortened their shot for the very purpose of getting that quality which they did not previously possess. But Captain Yonge's argument was founded on the supposition that no alternative was presented, that we must either take the Armstrong or Whithworth gun as a whole, or we must take the smooth-bore as a whole. We are not subjected to any such alternative by the physical facts. We say we want a rifle; but we want a rifle and a smooth-bore conjointly; and we must

have that, and that alone can be an efficient gun. But it is not simply that; if you were to put the question to any naval officer and say to him, "Would you rather have a gun that was more accurate from one yard up to a thousand yards, and less accurate from a thousand yards upwards, or a gun that was less accurate from one yard up to a thousand yards, and more accurate from a thousand yards upwards?" of course he would say at once he would have the gun that is accurate from one yard up to a thousand; it does not admit of a doubt. Again, Captain Yonge assumed that the difference in velocities was such that at six hundred yards the rifled shot passed the smooth-bore. That again was arguing upon what Captain Harrison stated that we prefer and we insist upon a 68-pounder as being the best gun. We only said that the 68-pounder was the best gun we were allowed to have, notwithstanding our continued remonstrances against being left with that unimproved gun; we have been insisting for a long time for an improved smooth-bore without success. We never said the 68-pounder was the right gun. Here are the results of a smooth-bore gun—Horsefall's.* The striking velocity of that gun at eight hundred yards is 1,285 feet. Now, mark, the highest velocity of Sir William Armstrong's gun at the muzzle is 1,220 feet; and it has to travel eight hundred yards losing velocity at every foot, and then of course it will be still less. We have only to square the velocities and multiply the weight of the shot, and we get the striking force of the respective shot. There is a fact in opposition to what Captain Harrison has given us as a fact with respect to the comparative experiment between the 110-pounder and the 68-pounder. Then Captain Harrison said, in which I entirely differ from him, that it was a fair trial; that the guns were put on an equality. Now, gentlemen, this question you will all understand. I would ask, "Would any person say, because two ships of the same size and weight were going at the same velocity, irrespective of their forms, that they must be driven by equal motive power, would say, in fact, they are going at the same velocity, it is all right, they are on equal terms?" Difference of forms makes a great difference; would any one say that the velocity of piston-rods was necessarily a measure of the power that drove them, irrespective of the weight that was driven or raised. Yet that is the position assumed by Captain Harrison. He tells us that the trial between Sir W. Armstrong's gun and the smooth-bore was fair, that the guns were on equal terms, because the charge was in similar proportion, that is one-fourth the weight of the shot. Upon what principle can we pronounce that to be equal? It is not equal. The tension arising from the detention of the missile in the rifled gun is such, that, though the strength of the gun is three times or four times the strength of the cast-iron gun, the former is burst. Therefore, there is a power of three or four times applied to that shot—no, I won't say applied to the shot—applied to burst the gun, in gross violation of the mechanical law, because it does not propel the shot. The action of the powder is to destroy the gun, and it does destroy the gun. I say the condition of equality would be to take the tension of the gun. Given an equal tension of gun, because all tension and all power resolves itself into money—or a certain sum of money—then we may use what quantity of powder we please, to get the velocity into our shot. Then only would the smooth-bore gun be placed on an equality. The high initial velocity of this shot will do double as much as that done by the Armstrong shot. There is the recognition of the mechanical law, there is fairness, by not attending to which, the money is thrown away. Now, my objection is not one of detail either to Sir William Armstrong's gun or to Mr. Whitworth's gun; it is a question of principle. I say they both violate a simple law. The worst application of a power that I know of in any of the guns that have been tried, is that in Sir Wm. Armstrong's, and the most uneconomical. Take an illustration. Mr. Bashley Britten's gun, with one-tenth the weight of the shot for the charge, gives an initial velocity of 1,209 feet. Sir William Armstrong, to arrive at the same result, requires a charge equal to one-eighth the weight of the shot. *Cui bono?* The result of which is he is obliged to have a stronger gun. Mr. Bashley Britten can fire his charge with a common cast-iron gun, and he does not burst his gun. Sir Wm. Armstrong does, because of the unmechanical and uneconomical character of his missile as compared with that of Mr. Britten. Now, we must have initial velocity, and we must have it at all costs.

* See Table ii., page 44.

TABLE II.

Comparative Table of Heavy Ordnance.

Name.	Description.	Diameter of Bore.	Length of Gun.	Weight.			Velocity.		Range. Elevation.		Penetration in inches.		Remarks.
				Gun.	Powder.	Shot.	Initial.	At 800 Yards.	5°	10°	200 Yards.	800 Yards.	
		Inches.	Feet.	Tons.	lbs.	lbs.							
Monster	Horsfall.	13	16	24½	75½	282	..	1,285	..	..	Smashed	Target.	Forged 1856
„	„	13	16	24½	50	..	1,631	..	2,433	3,530	„	„	
Armstrong	150-pr.	10½	12	12	50	150	1,766	..	..	..	Through to Skin.	..	Burst
„	„	10½	12	12	40	..	..	..	2,400	3,400			
Rodman		15	16	22	40	303	1,282	..	1,700	..	..		
Armstrong	110-pr.	7	10	4	14	110	1,220	..	..	..	1½	..	
Whitworth	120-pr.	7 × 6·4	12	7¾	27	150	(1,500 nearly.)	1,220	..	..	..	Through at 600 yards, through 4½-in. plates.	2·3-in. penetration of cast-iron projectile.
„	70-pr.	5 × 6 × 5·2	10	3¾	13	80	..	1,106	..	..	..		1·6-in. penetration of cast-iron projectile.
Old Smooth-bore	68-pr.	8	10	4¾	16	66¼	1,580	Shot	2,000	2,930	2¼		
„	„	8	10	4¾	16	51½	1,809	Shell.					

This cannot be obtained with Sir Wm. Armstrong's gun, without reducing the length of the shot, which involves a great reduction of the long range, which is the very principle upon which the smooth-bore was rejected; to shorten the shot is to give up the question. I say, give me the strength of the Armstrong gun, the power of applying a proper rifled missile, and such a gun as will admit of the use of round shot. This will admit of a long range and a higher initial velocity than he can obtain with the same strength of gun and *his missile*, and will admit other advantages that we contend for, the use of round shot, grape, cannister, shrapnel, and molten iron. I ask if that is not what we want to arrive at? Captain Harrison himself will not object to high initial velocity, if we only get long range. This arrangement will give high initial velocity, and long range too; another objection with respect to the form of Mr. Whitworth's missile is, that it not only cuts into the gun, but the force is exerted outwards and tends to burst the gun. If the face of the bore is made so hard that it won't cut, then something must give way, whereas by a proper system of rifling, such as is used by the French, such as is adopted in America, such as is suggested by Captain Scott, and such as is used by Captain Blakeley, the pressure, instead of bearing directly outwards, tending to burst the gun, is in the direction of the circle, the strongest direction in which it can be applied. In mechanism, the principle which should be followed, is that of obtaining results at the least possible expense, or if the force is given, that the force shall be applied in the best possible way; the strength of the gun being given, the less of the force applied to destroy the gun, and the more of the force, evolved from the powder, that is applied to drive the shot, the greater will be the result. What is the fact with respect to these guns? That of Mr. Whitworth is such a tight fit that the shot is retained for a time in the gun. In Sir William Armstrong's, because the shot is larger than the cylinder of the gun, it is retained still longer. The consequence of which is, that these guns are subject to very great initial tension. Now, a law of mechanics is that the more slowly and easily motion is communicated, the less the power that is required to give the motion. But in neither case can the shot receive motion slowly, in the latter the shot has to be forced through a space smaller than the missile in order to take the grooving, and the consequence is the highest initial tension; and when high initial velocities are sought by increasing the charge of powder, the vent-pieces blow out or the gun bursts—something must give. Whereas if windage were allowed, which, as was said by Captain Scott, is a safety-valve, we should escape these consequences. And, mark, this idea is not drawn from comparing one description of rifled gun with another, but will be seen by comparing the round shot together. For instance, a 150-pounder Armstrong was fired with 0·02—something exceedingly small; I am told that the shot was turned almost to a perfect fit. What was the consequence? The gun that was made for the purpose of carrying a 300-pounder shot burst with firing a 150-pounder, with a charge of powder of only one-fourth the weight of the shot. Now, if it would not stand that strain, how was it to have stood double the strain which double the weight of shot would have thrown upon it? With that same gun, if the windage had been increased, the shot would have strained the gun less, and the shot would have attained a much higher initial velocity. I say with respect to rifles, if you have a description of rifle-shot which will not depend for its accuracy upon a mere mechanical fit, or upon excessive tightness at the muzzle, either in the case of the shunt or in that of the multigroove, by being made larger than the cylinder and having to be forced into it, but a gun with a description of rifling which will allow of windage and grooves upon which the shot will centre, the moment the pressure comes on the grooves it will throw the shot into the centre of the gun; the accuracy, the initial velocity, and other qualities that cannot be obtained by any other, will be obtained by this plan, without any extreme tension on the gun. The consequence of which will be the power of using large charges, and then instead of having a very high initial tension we shall have a low tension brought on the gun gradually, and as the shot passes along the bore there will be, in consequence of having a large charge, a continuous explosion going on, giving increased velocity to the shot without bringing any high tension upon the gun at all. Therefore, it is upon broad, clear, unmistakable principles, that I say, that neither can Mr. Whitworth's gun, nor less still Sir Wm. Armstrong's gun, be considered either a proper gun for use or a gun that is constructed upon scientific principles, or

any other than one which is to be repudiated. They are expensive articles. Allusion has been made to the exceptional experiment, with respect to the large charge of powder with which the so-called 300-pounder was fired at the "Warrior" target. It was an exceptional case we know, as it was distinctly stated by Captain Scott that with the ordinary service-charges continually applied, this gun would yield; whereas this was an unusually high charge, and just in that exceptional case it did produce certain results. But if it will not stand the ordinary charges, *a fortiori* it will not stand the exceptionally high charges necessary for high velocities. But what is the fact with respect to the 68-pounder and its charge of 16lbs.? Some of those guns that passed into the hands of the French in the attack on Sebastopol stood two thousand rounds without fracture. A report of Russian officers states that Mr. Whitworth's gun fired twenty-five times, doubtless with high charges, and doubtless without the necessary quantity of grease (which Mr. Whitworth knows the value of in experiments), was found to yield. And in alluding to this application of grease, I would ask who is going to be using grease in action? Really they are not practical men who talk of these kind of things. I cannot understand how persons can imagine for a moment, that men in the height of action can have all these things at hand, and be particular in the use of them. The thing is absurd. When men's blood is up, they are excited, and the consequence is that men who are first-rate shots under ordinary circumstances, their firing becomes exceedingly bad in action. If at such a time these difficulties are to be added, such guns will be of no use at all. Then, with respect to accuracy on board ship; I was in search of pirates on the coast of China some years ago, I ran down and found eight of them in a little bay inside another bay. When they discovered us coming down they came out to fight, as soon as they ran out from under shelter of the point they found that there was a little more motion than they expected. They then thought that discretion was the better part of valour, and instead of fighting they endeavoured to make their escape. I had capital shots on board, capitally handled guns, and even the unparalleled 68-pounder among them, so that Captain Harrison would not be inclined to say I disparaged them, and for hours we were firing at these vessels without hitting them once. We then closed in upon them; we drove four on shore, steaming first in one direction and then in another, narrowing each time the space between us, making a dash at them when they attempted to get out. That will show how utterly useless it is to talk of the accuracy at long ranges which is contemplated, and for which we are expected to give up a comparative accuracy, but still, under unfavourable circumstances, no accuracy at all. I am sorry to have occupied so much of your time, but this is a *most important* subject. An anecdote must be my apology for having talked so long. Lord Abinger, the celebrated advocate, had a remarkable case, on which he spoke for many hours; his friends afterwards told him that they considered every man in the Court had been convinced four hours before he had finished. "Oh, no," he said, "the gentleman in the yellow waistcoat in the jury box was only convinced within the last five minutes, and if I had not convinced him I should not have had a verdict." I don't know whether there are any gentlemen in yellow waistcoats here, but I am sure there are outside, and that must be my excuse for having occupied so much of your time.

The next point is the question of defence. If any gentleman has anything to say upon defence, and the best modes of defence, we shall be glad to hear him.

Mr. Barrass, C.E.: If it will not be detaining you too long, I will just draw your attention to the plan which I had the honour of bringing before you a few days ago on a proposed mode of arranging the armour-plates on ships. My proposal is to effect such an arrangement of the iron work of iron-made ships, as will ensure in them, as in a wooden one, a uniform, or nearly uniform, thickness of material between wind and water, to resist penetration, and this thickness to be wholly of iron, to avoid the consequences of the electrical action which takes place in a mixed structure of wood and iron in salt water. In the arrangement of the iron, then, as I explained, there was a uniform thickness of iron between rib and rib, and between deck and deck of the fighting space, the ship being constructed in the usual manner below the water line, but having the ribs diminishing in number as each deck is approached, and each thickness of armour is applied, until, in the fighting space, there is only one rib between each port-hole, or something like about 15 or 20 feet apart, the ordinary distance

between the port-holes, and each main rib in the fighting space midway between the port-holes carrying the parallel thickness of armour, my view being, that if you have the whole of the iron in the fighting space resolved into a form which gives the same strength to the structure as the ribs would give, but with a maximum and uniform resistance to penetration, you are attaining the most eligible form of arrangement for an iron ship of war. For let it be observed, that in an iron ship, a large quantity of the material at command is absorbed in the ribs, and though you may increase their number, and certainly add to the transverse strength of the ship in pitching and rolling, and also to the transverse strength of the fighting surface of the ship's side, as a whole, still the ribs, as long as a shot can pass between them, cannot be said to add to the shot-resisting power of the ship, in fact, you may make the ribs so heavy, and put them so closely together, that you would not have the material left to place sufficient thickness to resist the shot to any appreciable degree. I propose, therefore, to place the armour-plates on to two other thicknesses as a backing, and united in a manner which I will explain presently, that you get such a mass of iron throughout the ship, between wind and water, that you can take away the ribs and use that material which would be required in their construction, in giving a parallel thickness to resist penetration. In the application of the system, then, it is proposed to put the first thickness of plates on throughout the length of the vessel in the usual manner, that is to say, longitudinally as regards their length, and increasing in thickness from the bilge upwards, as the liability to penetration on rolling increases, until, at the fighting space, the plates are armour-plates of the usual proportions, say about 16 feet long by 4 feet wide, and 3 inches thick. At this point, then, there is no organic change in the construction of the ship, save that, at deck after deck, a proportion of the ribs are stopped off at each, that their material or an equivalent thereto, may be reserved to increase the thickness of armour between wind and water. Then the second thickness of armour-plating is added, and is placed vertically, with regard to its length, and in plates, say again about 15 or 16 feet long by 4 feet wide. I do not remember the proportions precisely, but you will, I have no doubt, understand the project sufficiently—this second thickness being carried down to 6 or 8 feet below the water line, according as you may reckon upon the rolling of the ship, but having a good thickness at the line of general greatest immersion, then the last thickness of armour-plating is put on, the plates placed longitudinally again as regards their length, and of the usual proportions, 15 or 16 feet long by 4 feet or 4 feet 6 inches broad.

The CHAIRMAN: How do you joint?

First of all—the first thickness of armour-plates is jointed over the ribs, and having cover strips inside at the longitudinal joints a foot wide and 3 inches thick. The second thickness of plate is then rivetted to the first thickness, but breaking joint with it both with respect to the vertical and longitudinal joints as shown in the diagram before you, so that the joints of the second thickness are always over the solid plate of the first thickness. Then the third thickness of armour-plate is added, but united to the second thickness only, and with separate rivets to those uniting the first and second thicknesses, and placed in different positions, by which arrangement the rivets that are uniting the first and second thicknesses of plate are protected by the solid plate in front, so that the shot can never touch the first series of rivets and drive them inside. While in like manner the rivets which unite the second and third thicknesses are protected by the solid plate behind; the last rivets or those uniting the second and third thicknesses are turned to the shape shown on the figure, carefully prepared, the points well heated, driven in, and then trimmed off flush on the outside, so that when the vessel is finished, the rivets which are uniting the two outside thicknesses cannot be driven through into the interior of the ship, while those which are uniting the two inside thicknesses, cannot be touched at all, which at once gets rid of the difficulty of the through bolts, which, on a shot striking them, fly off, and are driven inside the ship. With reference to the relative advantage of wood and iron, I think the matter can be put in a very simple light. If it be true, which I suppose it is, that the resistance of wood and iron are as about their specific gravities, so far as the material is concerned, there is nothing to be gained or lost by the two materials. It appears to me in the construction of an iron ship you may as it were skin away the material from the bottom of the ship by putting in thin plates where you do

not want to have the material to resist penetration, and conserving that material up between wind and water. On the other hand in the building of a wood ship they are obliged to make the wood very thick down below, because in the building of a wooden ship you require, as it were, to depend more upon the mass. In an iron ship you depend upon the cohesion of the plates rivetted to each other. The system of armour-plating I propose, I think you will see is a very good one. It gives you a parallel thickness to resist the penetration as in a wood one, and without in any manner weakening the vessel; indeed, it adds to the strength of the vessel, because the vessel, by uniting the three thicknesses together, is almost like one solid mass of iron, so that, upon the vessel being strained, it is equally strong in every direction; but the principle item in the matter is the given uniform thickness to resist penetration. That is the principle point that I lay stress upon—an uniform solid thickness of about 10 inches.

I think there is one other point I may perhaps notice, and that is the great advantage which is considered to be due to the elasticity of the timber. There is no doubt that it is perfectly correct, that timber, being an elastic substance, does yield to the sudden impact of the shot, and in some measure, as it were, takes up by its elasticity some part of the momentum, and just in proportion as it takes up the momentum of the shot, it, as it were, shields the plate. Now, I fulfil the same condition here, but without the timber, and fulfil it in the manner which I have just stated, in the manner which gives strength to the vessel right away through, for by having the parallel thickness of material only supported at the two decks, and then supported by the two ribs, we have a parallel surface something like 20 feet by 10, and an elastic substance ready to yield to the impact of the shot, and I apprehend that by that elasticity we shall just give as complete a cushion to the impact of the shot, as you would have with the timber, while at the same time I get a mass of iron right away through, to resist the penetration, and give strength to the ship, and avoid electrical action.

Mr. CLARK: Not being a member of either profession, naval or military, I rise with some diffidence, but as a member has introduced me, I venture to make some remarks upon the subject of the proposition of the gentleman who has just addressed the meeting.

Commander SCOTT: Mr. Clark is constructing a target at the present time; he is one of those whose designs have been chosen.

Mr. CLARK: It is because I have considered the subject and had some little practical experience from attending experiments at Shoeburyness, that I venture to make some observations upon the proposal which is submitted to your notice. If I understand rightly, the plan just mentioned, it is founded in the first instance on the construction of a frame-work on a very large scale, to afford a bearing surface for a thick system of plates, each bearing upon its particular frame, which we have just been informed is to be in each frame 20 feet in length by 10 feet in height. I understand then it is to be a large and strong frame, supporting within its compass a system of armour-plates laid one over the other in three series, and conjointly presenting a mass of iron 10 inches in thickness. From the observations I have made on the experiments at Shoeburyness and their results, I venture to give an opinion, that that plan is founded on a material error as to the effect and action upon iron when struck by projectiles.

Before expressing my opinion upon that point, I will make a few remarks upon the system of construction. The wall of iron being composed of three layers, is in its nature similar to a plan proposed by Mr. Hawkshaw, and experimented upon at Shoeburyness, on targets which are now in existence there. He conceived the idea, that by riveting, and also by means of screw-bolts fastening together plate upon plate, a great thickness of iron could be attained at a moderate expense, looking at the enormous cost of the large and thick plates of iron which are considered to be essential for armour plating.

The CHAIRMAN: What thickness were his plates?

Mr. CLARK: His plates were half an inch to three-quarters of an inch in thickness, but he increased the layers one upon the other, to the extent of 10 or 12 inches. I am aware these are proposed to be 3 or 4 inches thicker, but still the principle is the same, and experience has shown that that application is an error in

principle, which, I must say, I am surprised that so eminent an engineer as Mr. Hawkshaw, should have fallen into. When a mass of iron is produced by overlaying plates one upon the other, you lose in the mass the cohesive strength which iron has when it is in one thickness. They are only sheets superposed one upon another, and if at the back of this congeries of sheets there is not a something to support the whole mass, they give way individually, they slip, as it were, over each other; the force is communicated from the first plate to the second, and each plate separately has only the strength of its thickness to resist the impact of shot. Such proved to be the result at the trial of Mr. Hawkshaw's target. Anybody may see it now. A 68-pounder went through it with the greatest ease, bursting all the layers of iron open, and offering no difficulty to the passage of the shot. By the by, I will venture to say a word in favour of the 68-pounder, because on that occasion the 110-pounder Armstrong could not produce that effect. The same target was fired at by the 110-pounders and by the 68-pounders, and it was the 68-pounder that did the mischief. That system, moreover, is greatly impaired by the perforations through the plates of the rivets. Another serious objection to that mode of armour-plating is the tendency which I am afraid would exist to the heads of the rivets flying off from the vibration of the iron. I am altogether opposed to wood-backing to iron plates, because it offers no effectual resistance behind the plate. But, unquestionably, the wood-backing produces this effect—it ameliorates, or rather prevents the effects of vibration. The plate lying upon a bed of wood, the blow is distributed over a large surface of the bearing behind, and the effect of vibration is materially prevented. Therefore, if you place plates of iron with distant bearings round the plates, especially as in this case, where the distances are so great as 20 feet and 10 feet asunder, with nothing behind to support this mass of iron, the vibration will be so great, that from the result of experience frequently repeated, the plates would be split in all directions. The damage to the plate by cracks would be infinitely greater than the effect of penetration, and I think the gentleman who has submitted that proposal cannot have witnessed experiments upon plates without any backing to them. I saw plates at Shoeburyness which were manufactured at the Portsmouth arsenal, hammered plates of the most admirable construction, made of the best kind of scrap iron, and they were fired at; plates on frames with no backing to them, but supported only by the edges. A few shot, not of the heaviest calibre, sufficed to smash those plates into atoms; they broke as a pane of glass would by a stone being thrown against it. In support of that view of the case it is a very well known fact, that if a rifle shot is fired at a plate of glass it will go clean through, by means of its immense velocity, without producing any crack, for this reason, that the action is so rapid, that vibration does not take place, and the hole is perforated without any er damage. My opinion, therefore, is that that system of armour-plating would an entire failure. I have come to the conclusion, and as a plan that is about to b. tested will soon show whether my conclusion is right or not—as it has been mentioned, I will just state the principle of it. I came to the conclusion from the result of experiments, that most of the ill-effects produced upon armour-plates—I allude to those upon the "Warrior"—resulted from the nature of the backing, the backing being a soft and yielding material, which offers comparatively no resistance to the effect of projectiles. When the plate is struck the immediate effect is a bulge in the plate, the wood offering no resistance whatsoever, being only one-tenth the density and hardness of iron; it is, to use the term, only one-tenth better than nothing behind the plate. In all cases even where the plate is not penetrated by the shot, when the back of the plate is examined there is a very extensive bulge fully twice the diameter of the shot. It is a singular fact that the blow imparted by the bulge to the wood transmits the force through the wood to the body behind, and the skin of an iron-plated target is slightly damaged by the transmission of the blow through the wood, and in the case of experiments upon the sides of the hulks at Portsmouth in testing armour-plates, as in numerous instances which I have seen, splinters of the wood have been sent right through inside the vessel merely by the transmission of the force by means of the bulge without the plate being penetrated. It was the observation of these facts which led me to consider the subject—what should be the nature of the backing? And I had the good fortune to witness the trial very intelligently made by the Armour-plate Committee upon plates of only 2½ inches in thickness

with various kinds of backing in order to test the effect of backing with reference to the same kind of shot fired against it. One plate had perfectly elastic backing, consisting of cork and kamptulicon, I think 2 to 3 feet in thickness. The second plate was backed with solid oak 3 feet in thickness; the third with granite, and the fourth with cast-iron blocks. The thickness of the plate being only 2¼ inches, it was fired at by a 40-pounder, which was considered from the experiments of the Armour-plate Committee to be the description of shot, with the proper charge for that shot, to force its way into the plate. The effect upon the plate with the elastic backing was as I have just now described, that of a stone thrown against a pane of glass, which smashed the plate, cracked it in all directions, went right through the whole, and came out behind; it passed through the whole of the bed, plate, backing, and all. The second being backed with oak, the same effect was produced upon the plate. The plate was smashed, the shot did not pass through, it stuck fast in the middle. The third, backed with a hard backing of granite; the shot rebounded, made a slight indentation about 3 inches in diameter and about half an inch in depth, cracked the stone, but did no further damage. When the shot was fired against the plate with a cast-iron backing, it recoiled from it like a pellet from a pop-gun, making a little mark and doing no damage to the plate. On a subsequent occasion these plates were again fired at with the 100-pounder, which of course was out of all measure and proportion to the thickness of the plate. The damage upon the elastic backing and upon the oak backing was still greater than with the 40-pounder; it broke a piece out of the plate with the granite backing, and with reference to the other one with the iron backing the shot happened to strike the top of one of the bolts nearly at the edge of the plate, and by that accidental blow on the edge of the bolt it caused the bolt to act as a wedge and it burst a piece out, not only of the plate but of the block of cast iron besides. But when afterwards the plate was removed and the condition of the backing behind was examined and the plate itself, there was a very slight bulge indeed, and by no means deep indentation in the plate itself. From these results I came to the conclusion that rigid backing was what was necessary. Evidently cast-iron blocks would not be carried on board ship, and, reflecting upon the subject, I came to the conclusion that the same result might probably be attained by an iron cellular backing, by the formation, as it were, of girders behind the armour-plate, between the armour-plate and the skin of the ship, and that is the principle which I have carried out in practice, and which upon representation to the Armour-plate Committee was favourably reported upon to the Admiralty, and the Admiralty finally determined to try. A target is now being constructed upon that plan and will very shortly be tested at Shoeburyness. The system of construction is this, that the angle irons forming the girders are placed horizontally outside the skin of the ship. They form longitudinal cells, which are narrow in width, upon the principle which I look upon as essential—that these cells should be narrower than the diameter of the projectile to be fired at the plates, so that when a plate is struck the formation of the bulge, or the bulge which tends to form at the back of the plate when it is struck, shall be received by two or three of the angle irons placed edgeways and presenting a resistance to the effect of the shot, in order to prevent vibration. At the same time, to increase the resisting power of the backing, these cells will be filled with wood with the grain end, or placed in blocks in the cells with iron wedges at short distances of 12 or 18 inches, serving to form a series of smaller cells in the longitudinal cells, and at the same time strengthening the walls of the cells by preventing their collapsing when they receive the blow. I have also been induced, by the result of experiments I saw at Shoeburyness with the article of mill-board, to the effects of which I believe Commander Scott has also turned his attention, to have some of the cells behind some of the plates on my target filled in with mill-board, and I have reason to think that its effective resistance will be greater than that of wood used for the same purpose.

I am afraid these details I am entering into, although they are for the public service, may be considered rather egotistical, as they refer to a plan of my own.

The CHAIRMAN: Not at all; they are very interesting.

MR. CLARK: I have many doubts upon the success of the trial, but I believe the plan involves a principle which ought to be tested, and the authorities are of the same opinion.

I have also another plan which refers to the fastening of armour-plates, so as to dispense entirely with through bolts. That may prove to have its merit; it also may have its disadvantage. My system of fastening is to cut a dove-tailed slot at the back of the armour-plate, and to reeve into that slot a dove-tailed bar, to which the plates are attached by welding them on to the bar, or they may pass through the bar. I do not know whether without a plan which I have not got with me, or any model, I can make the plan quite intelligible, but if I describe the mode in which it is applied, perhaps it will be better understood. I form a dove-tailed bar with bolts forged on to it, projecting from it at right angles. This bar is placed vertically on the outside of the skin of the ship, the bolts forged to it passing through their respective holes, which, of course, have been previously fitted. The inner end of the bar is provided with a screw and nut to fasten the plates. The plates being provided with dove-tailed slots, cut at their backs, and running vertically across the width of the plates, corresponding exactly in section to the dove-tailed bar, the plate is reeved over these slots, and when in its place, then the bolts are drawn up and the screws are made fast and the plate is drawn taut to its bearing. The inconvenience and disadvantage of that plan is, that with a plate of only, we will say, 4½ inches thickness, like that of the "Warrior," it is necessary to cut the slot at least 2 inches or 2½ inches into the plate; of course you reduce the thickness of the plate in that proportion, and that is considered by many engineers to be a fatal objection, that when the plate receives the blow it would split and crack in these parts. I confess I am of a different opinion, the slot being filled up solid by means of the bar, and brought to its bearing, unless the plate becomes distorted I do not think that any prejudicial effect will ensue. However, where a mechanical difficulty presents itself, there generally is some means of overcoming it, and I have devised one or two different means, one is in the formation of the plates, welding upon them or forging ribs on those lines of the plate vertically, where the dove-tailed slots are to be cut, so that the slot is not cut into the solid plate but is cut into the rib. Taking a 4½-inch plate, I superpose a rib 2½ inches in depth at the back, vertically at those parts where the slots are to be cut. I cut into that rib to the depth of 2½ inches. I obtain the whole depth for my bars without cutting into the solid plate; we then have to form the backing in the skin to receive the plate, and we have a solid and equal bearing by that means all over. By that contrivance I really render that part of the plate where the slots are cut the strongest, because, excepting the portion of the rib where the slot is cut into, it is 2½ inches thicker than the other portions of the plate, and if the inconvenience anticipated by cutting the slot into the body of the plate all of one thickness should ensue, I hope that by the contrivance of the ribs, the solidity of the plate will not at all be impaired. In connection with that subject, I will mention another principle which I consider of importance, and that is, that there shall be no possibility of motion in the plate by the shot striking at one end, and causing the other end to buckle, and I am inclined to believe, from the results of the trials at Shoeburyness, that the buckling which has produced such disastrous effects on the fastenings, results from the yielding nature of the backing; that the plate being struck at one end it buckles at the other, and so tears away the plates from the fastenings. I therefore use in my system smaller plates, not exceeding 6 or 7 feet in length, and hold them in so secure a way, that I believe the effect of buckling will not be produced, and that the great source of damage to the fastenings will be avoided.

I will not trouble the meeting with any more observations upon my system, but before I sit down, I will revert for a moment to the question of attack, to make a remark upon one point which, I think, may be of interest. I allude to the material of which projectiles are made. It is now apparent that the destructive effect of a projectile depends mainly upon the material of which it is constructed. The damaging effect of the Whitworth shot and the Whitworth shell is owing mainly to their being made of steel. Everybody understands that now, as we all understand things when we see them, with reference to an experiment that has been referred to as to the effect of the Armstrong 68-pounder.

The CHAIRMAN: The 110-pounder.

Mr. CLARK: I refer to that comparative trial of which I saw the effect, and with reference to that I am only raising an hypothesis; I do not know whether the effect

is true, but I have reason to think that the Armstrong 68-pounder shot was made, no doubt, of cast iron, but very carefully made, and as we have been told that cast iron may be so much improved in quality, that it will be equal or perhaps superior to wrought iron in its effect. Now, then, if the Armstrong 68-pounder shot was made of this improved cast iron, and the spherical 68-pounder shot was of the old rotten cast iron, that would tend very materially to account for the different effects produced, because the greater hardness of the metal would produce a much greater effect, as we saw with the Whitworth shell, than the round old 68-pounder could do, and it happens that a few days ago, last Friday, there was an experiment made at Shoeburyness with two shots which were supplied by a manufacturer at Sheffield, Mr. Making; these shots effected out of the Armstrong gun, what the Armstrong gun shot never did before; they penetrated the 4½ inch plate; they did not go right through it, but they stuck half way in, and there they are stuck in now. But what is that owing to? That is owing to the superior hardness of the metal; therefore, before we can determine whether the Armstrong shot really can do as much or more than the 68-pounder, we must be quite satisfied that the material for the projectiles is the same in both.

Mr. BARRASS: I think the gentleman has very much misunderstood what my proposition is. I am acquainted with what has been done at Shoeburyness, but I am not aware that there was anything like what I proposed, except Captain Inglis's plan, for the application of iron to forts and their embrasures, and whose plan consists of short slabs, 4 or 5 feet in length, and about 18 inches wide. They are very small in area, too small to stand much; they buckle up, as experiments at Shoeburyness and Portsmouth have shewn, while they are fixed with through bolts. And with reference to the rivet heads, I have no rivet heads at all. My rivets are countersunk, and are worked off flush with the surface of the plate after being rivetted, while with respect to the three thicknesses, my outside thickness is of the same proportion as that now used, 4 or 4½ inches in thickness, the only difference being, that my armour-plates are backed up with other two thicknesses for the reasons given, instead of being backed up, like the system in use, with wood and ribs behind an inner skin; so I think the gentleman who has just spoken has very much misunderstood what I proposed.

Captain SELWYN: I should have undertaken to answer some of Mr. Barrass' observations with reference to the thickness of iron plates, but that it has been so much more ably handled by Mr. Clark. I can only say in confirmation of what he has now stated, that I understand that a gentleman from America who should have been here to-night was prepared to state that he had seen no less than six inches of iron, I think I am correct in stating, pierced by the Whitworth gun, and the shot went on a mile afterwards.

The CHAIRMAN: It was Captain Blakeley's gun.

Captain SELWYN: You will pardon me for saying that what Mr. Clark has stated must inevitably apply to all superposed thicknesses of iron by reason of the same mechanical law, whether they be few in number or numerous, but all effect has been produced and will be produced in proportion to the thickness and specific gravity, you may say, of those plates. The whole question resolves itself, as Mr. Clark has stated, into one of specific gravity. If we increase the specific gravity or density of our materials, whether that be iron or steel, we produce a metal capable of resisting a heavier impact. In the case of soft metals we get from lead a very remarkable result; we get a very high specific gravity, an extremely soft metal, and all shot hitherto fired against thicknesses of lead in any proportion to the power of the shot fired have been broken up. In the case of steel shot, I should be prepared to expect that they would stick in it, more than break up. But it would be most interesting to have, what I believe we have not yet had, a plate of lead made of such thickness for a target as would be in some proportion to the heavy shot; it would probably, from all experiments on a small scale which I have tried, give us a useful standard of resistance. As to weight, the interesting progressive experiments with soft materials, with comparatively hard materials, and with extremely hard materials only, show us that what we call hardness or softness is a mere question of specific gravity. That question of specific gravity immediately attacks us seamen by saying, if you want specific gravity how do you deal with the weight? It matters little whether that specific gravity be put in the form of girders, in the form of cells, or in any other

form best calculated to offer resistance, but it must become at last and wholly a question of specific gravity. The only case in which it does not apply to its full extent, is that where it is not a homogeneous structure, and where, consequently, the tensile strength of the material is not available in every direction.

My reply to Mr. Clark must take a little the form of a question, and I should like to ask him whether he does not consider that in all these cases the specific gravity will be pretty nearly the measure of resistance? We have reached as I have said before, pretty nearly the limit of armour which we can carry, we are still but partially protected against shot, for in some cases the bows and the stern, where that most important thing, the motive power resides, are not protected, are open to attack still, and the vessel becomes utterly worthless if you take away that power. In the "Warrior,"—put forward as a magnificent sea-going man-of-war,—the first case which I can put in actual warfare, and which might properly belong to the manœuvring question, is that of a vessel coming up astern, catching her, and able to fire a concentrated broadside at her, which the chaser could evidently do before the chased could, owing to the round of the bow always being greater than the round of the stern, the chaser will always be able to concentrate his bow guns first, he will fire full at the screw, and if that screw is not protected, you will have no motive power to go on with. I need not refer to instances in confirmation of that. Therefore our protection has reached pretty nearly its limit, and it is of no use to talk of increasing the specific gravity of that armour if we find we have reached the greatest specific gravity we can carry. Again, the bottom, and that is very important, will be, by rolling, constantly and materially exposed. That bottom will be subject to damage from rocks or from straining, and if it be made of thin iron, if its value be ignored, I expect that we shall see another case of that unfortunate "Monitor" which has become, I think, what one might call a "caution."

Mr. BARRASS: I think you misunderstand me.

Captain SELWYN: She has gone to the bottom partly in consequence of the fact that, in iron ships more especially, given a certain size of leak, your leak increases faster by reason of the high specific gravity of the whole structure; a wooden ship springing a leak is not as much endangered as an iron armour vessel of an immense weight. It is most dangerous, therefore, to ignore the question of the bottom or materially to reduce the quantity of iron allowed for that portion.

Mr. BARRASS: I beg your pardon, I do not reduce it at all, nor do I propose to do so, I merely drew the comparison, or stated the relative courses of the two industries, as they generally obtain in comparing wood with iron, and stated what is actually done (not that you are obliged to follow this course of iron ship building in constructing an iron ship of war, because you are obliged to follow the usual course in building a wooden one), and so not having the same ratio of material down in the bottom of the ship in comparing wood with iron, and that, therefore, though the iron ship is weaker in the bottom than the wood one, you are not obliged to make the one weak because you are obliged to make the other strong, but that was all. I merely drew the comparison.

The CHAIRMAN: That is one of the elements of their weakness.

Captain SELWYN: That is, I think, the weakness of which we complain.

Mr. BARRASS: Exactly so, only that the ship is not made to run on a rock.

Captain SELWYN: A man-of-war, as I have learned all through my service, is made to stand any work that she may be called upon to do; and if any gentleman, not connected with the sea, will be kind enough to map out the rocks wherever they exist, I shall be careful to keep clear of them. Till that is done, we must expect to run these risks, more especially as we are called upon at all times to be prepared in the protection of the commerce of our country, whether it takes us on rocks or against the enemy's guns. I must give my cordial approval,—I humbly say my approval, though perhaps it may not be valuable to an engineer,—but as regards the ribs I consider that Mr. Clark has met the question of fastening plates in a most ingenious manner, because I think he will agree with me when I say that whether by rivet-holes, or by slots, or by any other means, you diminish the quantity of the material employed to give you resistance it matters little or nothing, the strength of the structure must be measured by that of the strength of its weakest point, and that is an engineering point, which I do not think Mr. Clark, as a talented engineer, as I believe him to be, will be disposed to

contest. I am sorry time does not in any way permit of my going into the question of the manœuvres, on which I have heard very little remark. It is a most important question, and I hope by some more able hand than myself it may be more fully treated, and in a manner to command a more valuable discussion.

The CHAIRMAN: We had better leave that for another paper. We are very much obliged to Captain Selwyn for introducing the paper which is not only pregnant with interest, but with valuable information, and has called forth some discussion which may be of use. Of course, as Captain Harrison says, when a man speaks strongly in one direction, he is immediately said to be a smooth borer; but my impression is that there has been a very bad fight made for the Armstrong. The arguments have been all on one side, the question ought to have a very speedy and complete decision, and I think Captain Selwyn has helped very much to bring about the desirable end. I have very much pleasure in returning the thanks of the members of this Institution and of the meeting to Captain Selwyn.

Captain SELWYN: I have one word more to say, and in this Institution, I should not wish to leave the room without saying it. It is this, that *this Institution* does represent—I hope will continue to represent—in a still greater measure a great portion of the talent and science of the two professions. That that science and that talent so collected together, may be more valued and more used by the Government of the country I fervently desire, for I am convinced that in proportion as they do so, they will encourage the development of that talent, and they will, at the same time, save the public from many and grave failures and fallacies, some of which have been already exploded by the action of this Institution. It is therefore deserving of the firmest support of the Government, and I think that the secretary has in his hand a letter from an officer of high rank now serving abroad, which materially confirms that impression. He says, in no measured terms, that the Institution is of the utmost use to both private individuals and the public in general. That being the case, I seek now merely to record a feeling which I may say prevails among the professions generally, that on professional points, professional men must be consulted, and that to their judgments the views, the principles, the schemes, or by whatever name they are called, of all inventors on these subjects, must be at last referred.

LECTURE.

Friday, February 27th, 1863.

Captain E. G. FISHBOURNE, R.N., in the Chair.

THE ERROR OF THE BOW GUN, AND OTHER ERRORS INCIDENTAL TO THE PRACTICE OF GREAT GUNS AT SEA.

By Benjamin Sharpe, Esq.

Having been requested by the Council of this Institution to deliver a lecture on "Gunnery," and the particular branch of the subject having been left to my selection, I have chosen for our consideration the "error of the bow gun," and other errors incidental to the firing of great guns on board ships, when inclined and in motion, and also the various requirements for the correct aiming of great guns at sea (the most intricate and important part of the science of gunnery).

A connection of some nine years with the gunnery establishment on board Her Majesty's ship "Excellent," while under the strict, but able rule of Sir Thomas Hastings, may, I trust, give me a claim to address you on these subjects. I must, however, beg your kind attention in this investigation, which although I have done my best to divest of technicalities, must naturally be remarkably dry, and were it not that the aggressive power of our fleets is so seriously involved, it might prove anything but interesting to unprofessional listeners.

We will now proceed to the consideration of "pointing" the great guns on board Her Majesty's ships of war, bearing in mind that it is the number of *hits* which measures the true force of a vessel, and that if by any improvement in the instruments of warfare, a ship can make twice as many hits as before, she will instantly become twice as powerful.

This important part of gunnery to which public attention was first especially directed by the action of the "Shannon" with the "Chesapeake," the successful termination of which was principally due to the great care bestowed by the captain of the "Shannon" (the late Sir Philip Broke) on the pointing of his guns, is even at the present

time so far from being in a satisfactory state (from many serious defects in the tangent sights, pendulums, and other means by which the seamen direct their fire), that I propose reviewing in detail the more prominent features in the system of pointing the great guns, as adopted in Her Majesty's navy, and showing, as I proceed, by extracts from works issued by the Admiralty and other authorities (such as Sir Howard Douglas, and Sir John Pechell) the importance of the particular points to which I am desirous of drawing attention, and I will then endeavour to point out how the various errors and deficiencies may be successfully overcome.

Amongst the most serious of these defects, is the "error of the bow gun" (as it is technically termed), which (with the single exception of the abeam position) pervades, as I will presently show, every part of the arc, and renders the present tangent-sights, not only useless in themselves, but a source of serious error to the seamen.

Horizontal fire (which is literally unattainable by any means at present in use) is another serious want, as is also the absence of any simple means by which the fire of such guns, as are not trained on pivots, may be directed at will to every point of the circle.

The subject of aiming great guns will be best divided under two principal heads; the one being properly termed "pointing," comprising the movements of a gun in the horizontal plane, the other called "elevating," relating to those which are in the vertical.

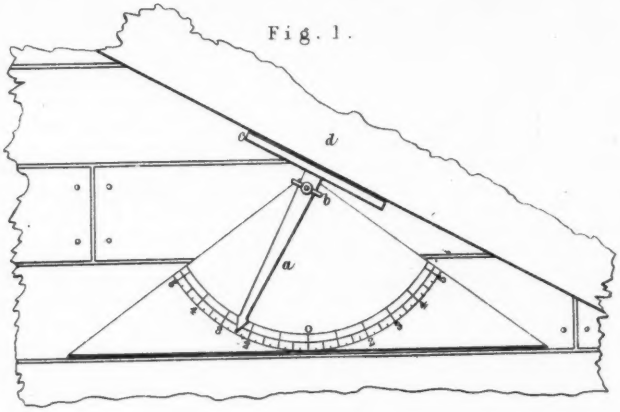
Taking the first, the movement in the horizontal plane is simply a directing the muzzle of the gun to the right or left hand by tackles and handspikes acting on the rear of the gun-carriage, and in the case of guns which work upon pivots (as carronnades, and the bow and stern guns of steamers), or on centres (as swivels), the motion of the rear of the gun-carriage being strictly confined to the arc of a circle, the position of the gun in its reference to the vessel can always be exactly defined by an arc divided into points, half-points, and quarter-points being marked on the deck, points having in practice been found preferable to degrees, these latter being exclusively reserved for the vertical plane.

The practice of marking the decks for pivot-guns (although unfortunately much neglected) has been commonly adopted by our best officers, but pivot-guns are rather the exception, the guns in the navy being usually mounted on the common gun-carriages with four trucks (which having no centres, or pivots to work on, will rarely occupy the same place in the ports when the guns are run out for firing). An arc marked on the deck would therefore be inapplicable in these cases; but guns mounted in this manner may be pointed with the same facility as pivot-guns, by means of an instrument which was used on board Her Majesty's ship "Howe," when under the command of the present Admirals Sir Watkin Pell and Robert Smart.

This instrument is termed a "pointer-board," and is triangular in form (plate I, fig. 1), and when in use (provided the seams run parallel with the keel) the base of the triangle is made to coincide with the deck planking, but whenever this is not sufficiently the case, then with lines parallel to the keel rased into the deck and filled with pitch.

POINTER BOARDS

Fig. 1.



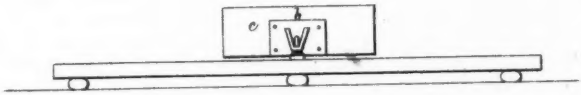


Fig. 2

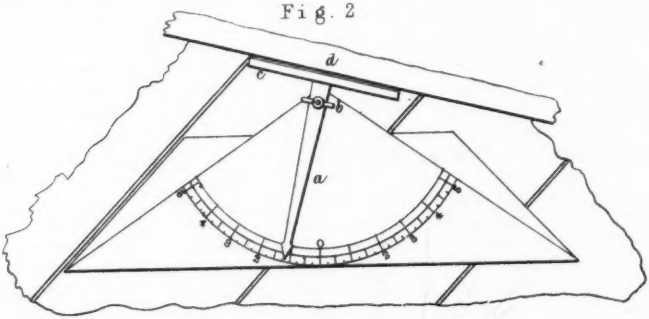
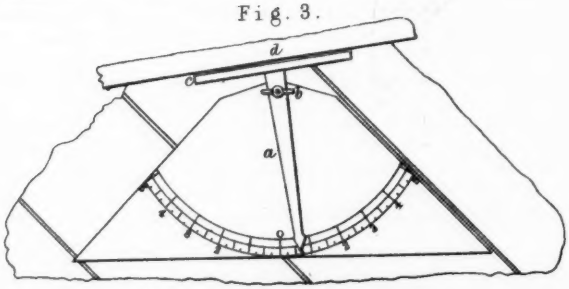


Fig. 3.



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Whenever a ship's decks are laid in a diagonal form, small wing-pieces (fig. 2) are added, and answer equally well, the outer portion of the wing forming the same angle with the base of the board as the diagonal seams with the keel, or the board may be shaped as in fig. 3. *a* (figs. 1, 2, & 3) is a moveable hand; *b*, a screw for tightening it when in place; *c*, an upright board fixed at right angles and above the hand, so that it may come in contact with the outer part of the rear axletree *d*, to any part of which it can be applied, and wherever, in fact, it will be most out of the way of the handspikes and train tackle. When not in use the pointer-board is kept overhead between the beams.

With these pointer-boards an officer in command may point his guns in whatever direction he may see fit, as, for instance, if engaging two vessels at the same time (which will frequently occur in a general action), he might order the starboard guns of his foremost quarters to be laid at $3\frac{1}{4}$ points before the beam, while the port guns of the after quarters were laid at 4 points abaft the beam, and then, as the bearings of his opponents from time to time varied (as seen from the upper deck), so could orders be transmitted through the voice pipes to the different quarters, and an immediate change in the direction of the fire be carried out by the captains of the guns merely altering the hands of the pointer-boards to the new bearings, and then training the guns until the rear axletrees again coincided with the upper cross-boards of the pointers.

It must be manifest that a power of training guns mounted on the common gun carriages to any part of the circle is absolutely indispensable, but as Captain Moorsom observes in his *Remarks on the Concentration of Ship's Guns*, "There is not at present any instrument supplied for showing the training of the guns," it is therefore difficult to conceive how a successful result to an action can be expected without any proper means for directing the fire; for should the wind happen to be light, ships become quickly enveloped in a cloud of smoke so dense, that when looking through the ports everything beyond the muzzle of the guns will be invisible; but whilst objects are thus shut out from the view of the lower batteries, a top-gallant-yard, mast-yard, part of a flag, or some portion of the gear aloft, may generally be seen from the upper deck sufficiently defined above the smoke to mark the position of a vessel, and enable her bearings to be accurately taken, either by compass, or by pointers fixed in a convenient position on the upper deck, and then transmitted to the quarters below.

The accounts we possess of different naval actions fought when the wind was light will strictly confirm this, and will show the extreme difficulty which has always been experienced in keeping up a continuous fire, on account of the dense masses of smoke which for a length of time hang about, and entirely obscure the object.

The same necessity for some means for laying the guns on a particular bearing would also be experienced at night, or in hazy weather, or when luffing up to discharge a broadside into a pursuing vessel, but the attention of inventors seems hitherto to have been principally occupied with various proposals for concentrating and converging the

fire of a ship's broadside, overlooking the more pressing need for some simple contrivance by which a ship's guns can be directed at will to every part of the arc.

As we shall have to refer to the subject of "*pointing*," in combination with "*elevation*," we had better first consider the movements of the gun in a vertical plane, or as it is technically termed the "*elevation*" and "*depression*" of the gun; these terms denoting the angle which the bore of the gun makes with the platform or deck on which the gun-carriage is placed. A vessel inclining to the wind will require her weather guns to be depressed, and her lee ones to be elevated in relation to this platform, to bring them all to a common level; besides this, there is another and distinct application of the term "*elevation*" (but without "*depression*" in conjunction with it) which refers exclusively to the angle which the bore of the gun makes with the horizontal line, or plane of the sea, whenever it is raised above that line for the purpose of extending the time of the shot's flight, and has no connection with any elevation which has been given to compensate for the heel of the ship. The movement of the gun in a vertical plane is therefore of a twofold character, and as the mechanical appliances which the two cases require are essentially different, they had better be separately dealt with.

Taking the first case where elevation or depression has to be given to compensate for the heel of the ship, the object to be fired at (being within the point-blank range) is brought in a line with the point of the dispart, and notch on the base-ring of the gun, the operation being extremely simple, and merely requiring the breech of the gun to be raised or lowered until the proper direction has been found; but it constantly happens, as already mentioned, that the object to be aimed at cannot be seen at all from the ports, and it then becomes necessary to have some standard of immediate reference by which the actual position of the bore of the gun in its relation to the plane of the sea may be ascertained at any moment during the incessant and complex movements of a ship at sea; and such a standard can only be obtained by means of a pendulum, or some other gravitating instrument, which, by constantly retaining a perpendicular position, will always show the inclination of a vessel, and the difference between the plane of the deck and the plane of the sea.

Pendulums have in fact been the instruments usually adopted, but owing to their faulty construction they have never obtained much favour; a ship has usually a single pendulum attached to the wheel standard, which is only available for the few guns in its immediate vicinity, the great bulk of the guns being left totally unprovided for, and yet the Admiralty admit in their *Questions on Naval Gunnery*, "that the elevation might be more correctly obtained if under the control of a pendulum attached to *every five or seven guns*." It is therefore much to be lamented that so important an object as horizontal fire has not been properly provided for.

One of the faults in the construction of the present pendulums is the absence of any means for counteracting the effect of the pitching and scending motions, in consequence of which the weight attached

to the index hand is alternately detained or relieved, as either of these motions causes it to press against the back of its case, and if, during the time of its detention, the ship have acquired a greater degree of inclination, the weight, when it becomes released, will suddenly fall to leeward with a jerk, in its endeavour to resume a perpendicular position, and will then mark a greater degree of heel than the ship may actually have at the time; but however perfectly this defect may be remedied, the present pendulums will still only give the direct heel of the ship, and therefore will only be applicable for such guns as are to be pointed at right angles with the keel, or "*right abeam*" (as it is usually termed), for the moment the guns are trained to the right or left of this position, the pendulums will cease to apply, as the muzzles of the guns, if on the weather side, will begin to descend below a line parallel with the plane of the sea, or if on the lee side, to rise above a similar line; as for instance, taking a lee gun and the ship heeling over ten degrees, a gun pointing "*right abeam*" would require an elevation of ten degrees above the plane of the deck to compensate for this heel, and to bring its bore horizontal or parallel with the plane of the sea; if then, without changing this elevation, the gun were trained to the right or left, until it pointed directly forward, or directly aft, it would, instead of being horizontal, be found pointing at an elevation of ten degrees above the horizontal line (less of course the inclination of the plane of elevation) having gradually acquired this elevation, as it were trained along the arc; so that except for the single position of "*right abeam*," the pendulums at present in use in the navy are for all gunnery purposes practically useless, horizontal fire being unattainable with them, and yet a very trifling increase or diminution in the inclination will make a very considerable difference in the range, as may be seen by the following extracts from the tables of ranges given in the *Naval Gunnery Questions*, there being a no less difference than 2,600 yards between the point-blank range, and the range for an elevation of ten degrees, or about an average difference of 300 yards for every degree.

Range for a 32-pr., 56 cwt., 9ft. 6in., 10lbs. of powder.

¼	1	2	3	4	5	6	7	8	9	10
343	800	1223	1513	1803	1950	2100	2361	2623	2761	2900

But as an example in point, the following extract from Clarke and McArthur's "Life of Lord Nelson" will show how completely the fire of the French and Spanish ships at the battle of Trafalgar was thrown away by the rolling motion alternately increasing and diminishing the range of the shot.

Vol. 2, page 449—"The enemy's fleet, by keeping with the wind nearly on their beam, lay in a trough in the sea, and rolled considerably, so that one broadside passed over, and the next fell short of their opponents,"—from which it must, I think, be evident that the use of

pendulums to indicate the moment for firing, would have prevented such a wholesale loss of power.

And in concentrated, or in converging fire, the deck is so constantly varying from the horizontal line as the vessel inclines to the pressure of the wind, that a pendulum becomes indipensable, the instances being rare when guns can be fired from a vessel in an upright position. A ship is, moreover, steadier while inclining under a moderate pressure of wind on her canvas; but the common pendulums will be useless in all such cases as these, as each gun, being of necessity trained at a different angle, will require a different amount of elevation or depression to be given it before the fire of all the guns can be brought to a common level.

It happens also occasionally in distant firing that the tangent-sights become useless, when the elevation due for the distance must be supplied by the quoins, or some other similar means, but which, unless aided by a pendulum, will be of little use, as only giving the elevation of the gun above the plane of the deck, and not the elevation of the gun above the plane of the sea; and again it is frequently the case from the ports not admitting a sufficiency of elevation, that inclined planes have to be placed under the rear-trucks, so that the muzzles of the guns may dip down and clear the upper part of the ports while the guns are in the act of recoiling; but the upper part of the port will in such a case intervene between the eye and the object, and necessitate a resort to quoins, or other such means (as in the last case), but which, unless aided by some gravitating instrument, will be powerless to give the elevation above the plane of the sea; that plane is manifestly the starting point, and for insuring a correct aim it is absolutely indispensable that its position should be exactly defined at the instant of firing.

Sir Thomas Hastings many years back pointed out the necessity which existed for using pendulums to denote the heel of the ship (as may be seen at page 30 of the *Questions on Naval Gunnery*, issued by the Admiralty), the quoins, side scales, &c., being entirely dependent on them for correctness. He says—

"There are several auxiliary sights which may be used beneficially "when the object cannot be seen, for instance, beds, and quoins, and "gun-scales duly marked by a spirit level, the ship being motionless, "and the guns being run out in their proper ports; *but to insure cor-* "*rectness in using them, it is necessary to employ a pendulum to mark the* "*heel of the ship.*

Also (at page 31), "The elevation might be more correctly obtained "under similar circumstances if the different divisions of guns were "placed under the control of a pendulum attached to every five or "seven guns to direct the moment for firing. The man looking out for "the pendulum should indicate the time for firing by some recognised "and distinct signal, by which means horizontal fire would be insured."

Sir Howard Douglas also alludes to the subject of pendulums in his work on Naval Gunnery (at page 218)—

"*Article* 175—Expedients for Regulating Horizontal Fire.

"It very frequently happens that ordnance cannot be pointed

"accurately by sight, particularly in general actions, on account of "the smoke in which the hulls of the contending vessels are usually "enveloped;" and after describing the system of marking side-scales adopted by Sir Philip Broke in the "Shannon," Sir Howard Douglas proceeds to state in allusion to this system:—

"*Article* 176—This ingenious expedient was also practised by other "gallant officers from the example of its distinguished author, and "it is described in Captain Pechell's tract. But, although this con- "trivance approximates considerably towards accuracy, yet there is "still the motion of the vessel to interfere with it, and consequently, "if no view of the enemy's hull can be had, and there be any motion, "the precise moment is not indicated at which the ordnance come to "horizontal directions. Now in close action, in moderate weather, or "in engaging to leeward, the enemy's hull is commonly so effectually "concealed in the smoke of both parties, as to be invisible, excepting "perhaps by the flashes of his guns, yet his position may frequently "be ascertained by his masts being discernible above the rising "smoke, when neither the hull, the horizon, nor the surface of the "water can be seen; and, consequently, when there is no guide "to point out the precious moment for firing with any certainty "of effect."

Sir Howard Douglas then describes an iron pendulum to be attached to the guns themselves, but this pendulum is found to fail in practice, as the pitching and scending motions cause it to press against the gun-carriage; it is besides greatly in the way of working the gun, and liable to injury.

These extracts will show how far back attention was first directed to the points I have been bringing under consideration, and the great importance these distinguished officers attached to them; but the quotations will not be complete without a few extracts from Sir John Pechell's tract already referred to by Sir Howard Douglas:—

"When the guns are received on board, a proper person should "accompany them, to see they are all placed in the ports appropriated "for them. The ship should be placed perfectly upright, the guns "run close out, then laid horizontal with a spirit level; as from the "unevenness of a ship's decks, this cannot be done on shore, a circum- "stance I conceive to be of great moment, it seldom happening after "a ship is once fitted out she can be found steady enough to do "it with the precision requisite to determine so important an object.

"It will easily be conceived how desirable it is when a ship is under "sail and likely to have a running fight, or if she is in action in "smooth water, or engaging a battery, or if she have occasion to tack "or wear, when the range is once determined, that an officer should be "able to direct *all* the guns in a ship to be elevated or depressed "alike. We have lately had an opportunity of knowing the good "effects of this being attended to in the action of the 'Shannon' "and the 'Chesapeake;' the guns of the former were all laid by "Captain Broke's directions; consequently the fire was thrown in a "horizontal line, not a shot going over the 'Chesapeake.' Had "Captain Broke, however, trusted the laying of them to the

"captains of guns, it cannot be supposed the 'Shannon's' fire "would have been thrown with such admirable precision, notwith- "standing her men were better trained and understood gunnery "better than any men I had ever seen. If this had been attended to "and adopted before, half our long and hard-fought actions might "have been finished in as little time as the 'Shannon's.' The "'Chesapeake' was beaten in eleven minutes, and taken in fifteen. "It is therefore to be hoped the Board of Ordnance will attend "to a circumstance which is so-well calculated to inspire the officers "and seamen with confidence, and to preserve a naval superiority. "Of late years we have had few enemies to encounter, who were "equal to us. It cannot be said that a French frigate (which had "never been at sea with half her crew fresh conscripts and brought "to action perhaps the very day she came out) was a fair trial "of strength, and therefore from our easy conquest of such ships "as these, we have unfortunately (until we were convinced of our "error) thought a British frigate could take anything with one deck. "The American ships have more officers and men than ours, and great "attention was paid before the war to the instruction of the seamen "in gunnery.

"(Signed) S. JOHN PECHELL,
"Bermuda, 6th May, 1814. H.M.S. 'San Domingo.'"

Having given these very excellent remarks by Sir John Pechell, I will now proceed to describe a pendulum, which, with other inventions, was awarded a prize medal in Class XI at the International Exhibition of 1862, by a distinguished jury, presided over by Lord Vernon, and which Sir Thomas Hastings, who is properly considered our highest authority in naval gunnery, has pronounced to be the best he has seen for gunnery purposes, and I have little doubt the instrument will be found, on examination, to justify his opinion, and to meet all the requirements of naval warfare, and as it will show, at every point of the circle, the number of degrees of elevation and depression required to bring a ship's guns to a horizontal position, it makes the much-desired horizontal fire at once attainable, and it will also very considerably increase the accuracy and effect of a concentrated or converging broadside, and, indeed, without a pendulum, a concentrated broadside, with a ship heeling over, is an impossibility.

One of the principal features in the construction of this pendulum is the horizontal movement of the vertical plane in which the pendulum itself acts, so that whenever this plane is pointed in the same direction as the guns, the pendulum will indicate the exact number of degrees of elevation or depression required for that particular bearing.

a, figs. 1 and 2, plate II, is a circular board, having its edge graduated to points, which is affixed between the beams (*i, i*) to the deck (*s*) overhead, the instrument being placed in this position that it may be kept free from injury, and out of the way of everything passing underneath; *b*, is a metal frame which revolves at *e* (the centre of the circular board *a*) being retained there by a key at *c; d* is a board graduated to degrees, which oscillates freely on two small pins, *l* and

THE TRAINING PENDULUM.

Fig. 1.

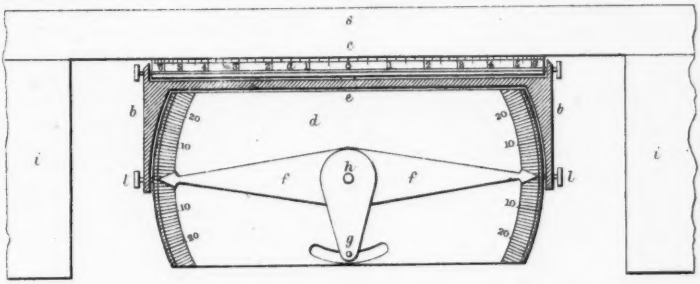
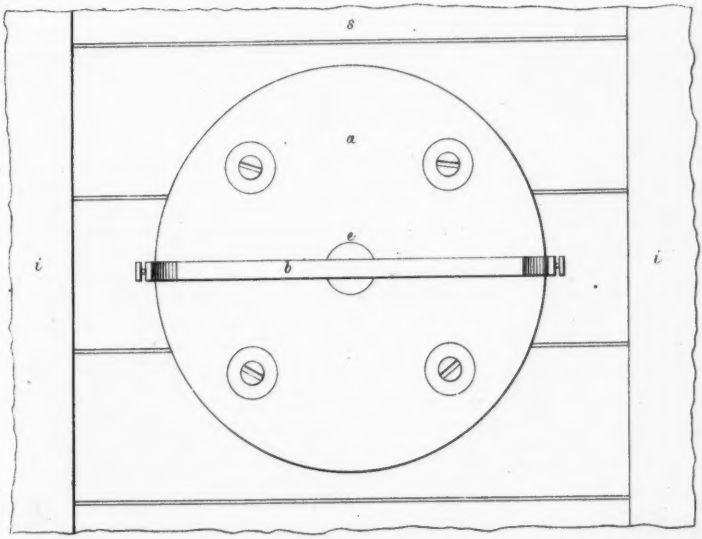


Fig. 2.



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THE TRAINING LEVEL.

Fig. 1.

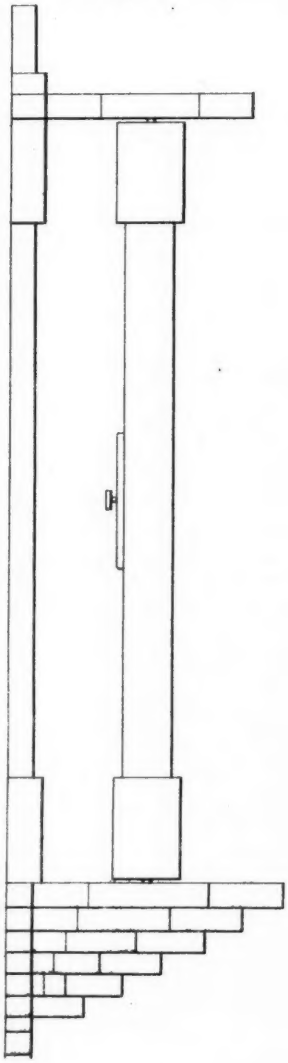
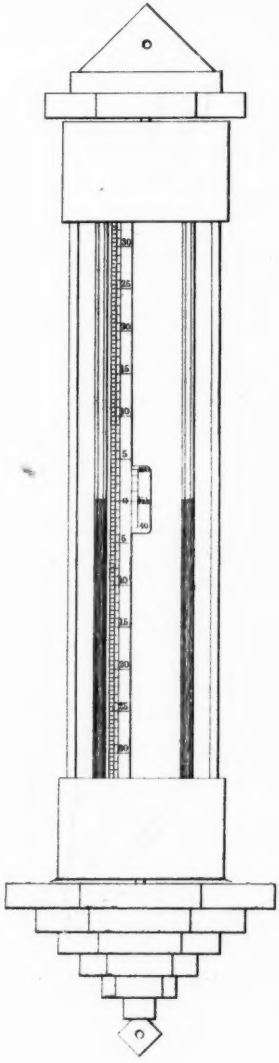


Fig. 2.



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l, and from being slightly weighted at the bottom, retains a perpendicular position, by which the pitching and scending motions are rendered nugatory; *f* and *f* are two hands which point to the degrees; *g* is a weight for keeping the hands in a horizontal position; this weight is made to pass through an aperture in the board *d*, and to connect with a similar pair of hands on the other side of the board; *h* is a pin which also connects the hands, becoming a centre on which they oscillate freely; *i* and *i* (figs. 1 and 2) shew sections of the beams, and *s* a section of the deck overhead.

The pendulum, as here represented, is for the purpose of better describing it, left pointing in a fore-and-aft position, in which it will merely shew the pitching and scending motions; its usual place would be lying athwart-ships with its index-pointer at *o* on the circular board, where it will shew the direct heel of the ship.

When the pendulum is required for gunnery purposes, and (by way of example) an order has been given to lay the guns $3\frac{1}{4}$ points abaft the beam, the metal frame must be moved round until the index-pointer has been brought to the $3\frac{1}{4}$ points on the circular board; the perpendicular board will then be in the same direction as the guns, and the double hands will then shew the number of degrees of elevation or depression required by the guns to bring their bores to the horizontal line, and thus, by this very simple (but hitherto unattempted) contrivance of training the pendulum itself in the same direction as the guns, will the supposed insurmountable difficulty of giving the proper elevation or depression to guns which have been trained to the right or left of an abeam position be successfully overcome.

Plate III, figs. 1 and 2, shows another description of gravitating instrument for the same purpose as the last, the action in which is obtained by coloured spirits and quicksilver being confined in a tube, the internal diameter of which is made to vary to the extent required for the length of the degree, which latter (if required) might be easily made even an inch in length. The instrument has been tested in the heaviest weather, and reported on most favourably by Admiral Hope. [*Appended at the end.*]

But to resume,—the inclination having been correctly shewn by the pendulums, is transferred to the guns, which are elevated or depressed until the quoins, side, or rear-scales, mark the same number of degrees.

This method is, however, far from being sufficiently correct for accurate practice, as a very little consideration will shew that a gun when working on its trunnions while a ship is inclining, must, of necessity, move in an inclined plane, the inclination of which is constantly varying as the vessel inclines to the wind, whereas the required angle must be measured in a vertical plane, which this method of measuring the angle will not accomplish, and besides, they are all liable to be affected by the wearing away of the deck and of the trucks (both externally and internally), and whenever the trucks have to be taken off, and the guns fought on their cleats, which will constantly happen (both to obtain a greater degree of elevation and to

moderate the recoil), they become absolutely useless. The following method will, however, obviate the difficulty:—

In this case, a beam over the gun, having a horizontal line marked on the side of it, has been adopted, instead of the deck below, as a point to measure from, as the usual curvature of the deck will always interfere with the carrying into practice of any theory depending on the deck being a perfect plane. This line will form a permanent standard, and whenever the line of dispart is parallel with it, the bores of the guns will be in a plane at right angles with the masts of the ship.

Instead of a line overhead, it would be more complete if two carlings were fitted between the beams, the one over where the dispart and the other over where the base-ring would be when the gun was run out for firing, the under-side of these carlings forming a plane at right angles with the masts, and occupying a wider space than a single beam, would always be over the guns in whatever position they might be trained, and thus supply a permanent standard; a transfer of the required elevation and depression to the guns will then become simple enough, and it is managed either by the usual scale, or by what perhaps would be preferable, by a scale hanging suspended from, and sliding freely on an iron rod taking the form of an arc, and attached to the under-side of the carlings; a small brass tube having a graduated scale sliding up and down it, would probably form the best kind of measure, and, when not in use, the scale might be hooked up out of the way; a separate scale, hanging in a similar manner over the dispart, is used for detecting (whenever required) any variation that may exist from a strictly parallel line, so that an immediate adjustment of the rear and working scale may take place. The manner of using this scale will be precisely the reverse of the present practice, the scale being suspended from the deck above, instead of resting on the deck below.

By this system of using a permanent scale overhead, the necessity for spirit-levels, and other similar expediments, and which at best can only apply to an abeam position, is entirely done away with.

Having now sufficiently dwelt on horizontal fire, and the movements of a gun in the vertical plane while within the point-blank distance, the next point is the various requirements, when the object to be fired at is beyond that distance. In this latter case the muzzle of the gun must be raised above the horizontal line to prolong the time of the shot's flight and counteract the action of gravity, and whenever thus raised, the muzzle will naturally intervene between the eye of the person aiming, and the object aimed at; a piece of metal, termed a tangent-sight, has therefore been raised above the breech of the gun, from the top of which the object will again become visible; the sight has degrees marked on it, to which ranges, formed by previous experiment, correspond, and it can be raised or lowered as required for the distance of the object.

As the sight is a fixture to the gun, it is manifest that whenever the gun is depressed or elevated, it must move up and down with the gun, and can therefore, supply correct elevation and depression only

so long as the gun is upright, with its breech moving up and down in a vertical plane, for the moment this plane inclines to either hand (although the object aimed at will continue to coincide exactly with the points of the sights) the shot, when discharged, will be thrown to the side towards which the plane inclines, and which constitutes what is technically termed "the error of the bow gun."

This error from the fact of the object continuing visible from the points of the sights, is therefore, of the most deceptive character, and is moreover, not confined merely to the bow and stern guns, but (with the exception of the abeam position) pervades the entire arc; it is at its maximum when the firing is directly ahead or astern, and at its minimum (or, in fact, ceases altogether) when the firing is directly abeam, in which latter position, when a ship is heeling over, a gun can alone work on its trunnions in a vertical plane; but to obtain a clearer conception of this somewhat intricate problem, we will take the case of a gun firing directly ahead or astern in a line with the keel, with the ship inclining, say ten degrees, the deck or plane on which the gun-carriage rests, will then incline ten degrees from the horizontal line, and the plane in which the gun works on its trunnions (being perpendicular to the deck) will also incline ten degrees, and provided the gun has been laid by line of dispart within the point-blank range, there will be no error, and the inclination will not in the least interfere with a correct aim; that this is the case we may soon prove by looking along the line of dispart (which is a line parallel with the centre of the bore), for although the line of dispart, owing to the inclination of the ship, will not then be on the upper side of the gun, it will not signify, for whether it be on the upper part, on the side, or on the lower part of the gun, it will in either of these positions equally well direct the aim, and provided the shot is propelled in a straight line towards the object aimed at, the shot will strike, not the object, but at the same distance from the object, as is the line of dispart from the centre of the bore.

It is requisite to perceive this clearly, as the error of the bow gun arises solely from the use of a fixed tangent-sight when a ship is heeling over, and the bore of the gun has received elevation for increasing the range of the shot.

We will now take a bow or stern gun under the same circumstances of 10° heel in the ship, and will assume the distance of the object to be fired at to require 10° of elevation, that the tangent-sight has been raised to this height, and that the object has been brought on in the usual way with the points of the sights.

It will now be seen, by looking in the direction of the line of dispart, that instead of pointing at the object, the gun has really been directed to the side of it, and to the side of it would the shot be thrown, if the gun were fired.

While aiming with the ship in an upright position, the fire would be perfectly accurate, but as the inclination of the ship and elevation of the gun increased, so would the deflection of the shot to leeward go on increasing; and if, for instance, instead of 10°, the gun had 90° of elevation given it (the ship having still 10° of heel), a shot would

then be thrown at right angles with the keel, or at 90° from the direction in which it was supposed to be pointing, and at an elevation of 80° above the horizontal plane.

Such an example as this is merely given to show, that as a gun becomes elevated, it will move round the entire quadrant of a circle, away from the object at which it was first directed, and consequently, when a ship is heeling over, and the firing is beyond the point-blank range, the present tangent-sights are both useless and a source of most serious error to the seamen using them.

In estimating the extent of this error, it must not be quietly assumed that because a certain amount of deflection is attached to a certain range, that twice the range will only have twice this error, for if, for instance, we take an 8-inch gun of 65 cwts. with 10 lbs. of powder, we may see by the table of ranges that a distance of 630 yards will require 1° of elevation, and that five times that distance, or 3,150 yards, will require, instead of 5°, no less than 15½° of elevation. "The error of the bow gun" is, therefore, of the gravest character, as it increases most rapidly in distant firing, where accuracy of aim is most essential.

It may have been observed from what has been stated respecting "the error of the bow gun," that there are two distinct causes of error to be considered, the one arising from the heel of the ship, the other from the elevation given to the gun, and that these errors act independently of each other, as for example, if a ship heels over 10°, where the distance requires an elevation of 5° on the tangent scale, the amount of error consequent on that inclination and elevation, would be increased if the scale were raised another degree (although the inclination of the ship might continue the same), and in like manner the error would be increased if the reverse were the case, and the inclination of the ship became increased, while the height of the tangent-scale remained the same.

Before proceeding further, it may be desirable to quote what the Admiralty has said on "the error of the bow gun," and the following extract, alluding to this subject, will be found in the *Naval Gunnery Questions*, issued by their Lordships :—

—— "It has been shown by Question 68, that it is necessary a gun "should be placed fairly on its carriage, so that its axis may be "directly under the line of metal, for which purpose the wheels or "trunnions should be of equal height. This cannot be the case when "firing ahead or astern in ship's heeling over, as the same conse-"quences would result from it; the axis of the gun would not be in "the same vertical plane as the line of metal, and the shot would be "thrown towards the side on which the trunnions were lowest, or, as we "should say on board ship, to leeward of the object aimed at; this can "only be compensated for by ascertaining the distance, calculating the "deflection and pointing to windward of the object, according to the "distance and elevation. (Vide formula annexed)—

"Formula { Loss of elevation = versed sine of angle of heel.
Deflection is as the sine of the heel with the height of the tangent-scale as radius."

"The elevation of the tangent-scale will, at the same time, be "lowered by the heel; but this error is not of such material impor- "tance as that caused by the deflection of the shot when firing ahead "or astern."

The error has, therefore, been fully recognised by the Admiralty, but in the absence of any simple mechanical means for correcting it, neither their Lordships or Sir Thomas Hastings could well do more than direct attention to the important bearing of the subject on accuracy of aim. General Stevens, of the Marine Artillery, another writer on gunnery, has also drawn attention to the deflection of the shot in chase-firing. He writes—

—— "Chases being necessarily made under a press of sail, the "pursuing and pursued vessels have generally a considerable heel; in "consequence of which, the guns in the bow and stern of each are "inclined to leeward from the upright position; the result of this will "be, that when firing at an elevation, the shot will fall, or be appa- "rently deflected to leeward of the object pointed at." He also writes—

"In addition to the above causes, by which shot fired from bow or "stern guns, of a vessel having a heel, are misdirected, the wind acts "in the same direction, and tends to throw the shot to leeward. "These two causes of error ought not to be neglected, since they "operate precisely when accuracy of fire is of most importance, and "their amount is *far greater* than many who have not investigated "the subject would perhaps suspect; for supposing one frigate chasing "another, the ship's heeling 10°, and the elevation required for the "guns to be 2°; under these circumstances, the shot would pass "*eighteen feet and more* to leeward of the point aimed at, and this too, "without considering any effect from the wind, which would be con- "siderable on the shot.

"In the preceding pages, tangent-sights have been described as "correcting the errors arising from a ship's motion, as it affects "pointing guns; so far as relates to errors of *elevation*, they may "be so *considered;* but not as to those of *direction*, caused by a *heeling* "motion on guns mounted at the extremities of the ship, and firing "directly forward or aft, or those occasioned by a *pitching* motion on "guns mounted on the broadside." He then gives, as he terms it, an *approximating* theorem:—"The following is an *approximating* theo- "rem, which will serve to show sufficiently the amount of the shot's "deviation from the apparent direction, under the different circum- "stances of the inclination of the plane, the gun's elevation, and "the range of the shot.

"Theorem $R \times T \times S = D$.

In which R = range in feet.
T = tangent of tabular elevation.
S = sine of gun's elevation.
D = lateral deviation from apparent direction in feet.

"Example—A ship heels over 10°; she is firing her chase-guns at

an object 1,000 yards, or 3,000 feet, distant. Required the shots deviation.

R 3000 feet	Log. 3.4771213
T tangent 2°	8.5430838
S sine of 10°	9.2396702
D = 18.191 feet	1.2598753

NOTE.—20 must be subtracted from the index.

If we now take this formula, and apply it to the case already described, where a ship heels 10°, and the distance of the object is 3,150 yards, requiring for the eight-inch gun of 65cwts. and 10lbs. of powder an elevation of 15½°, and proceed to calculate the error, we shall have the following startling result, that at this distance (which is literally nothing at the present day) we shall have a no less error than 455 *feet of deviation* to leeward of the object aimed at, and which is caused entirely by the inclination of the ship acting upon the present tangent-sights.

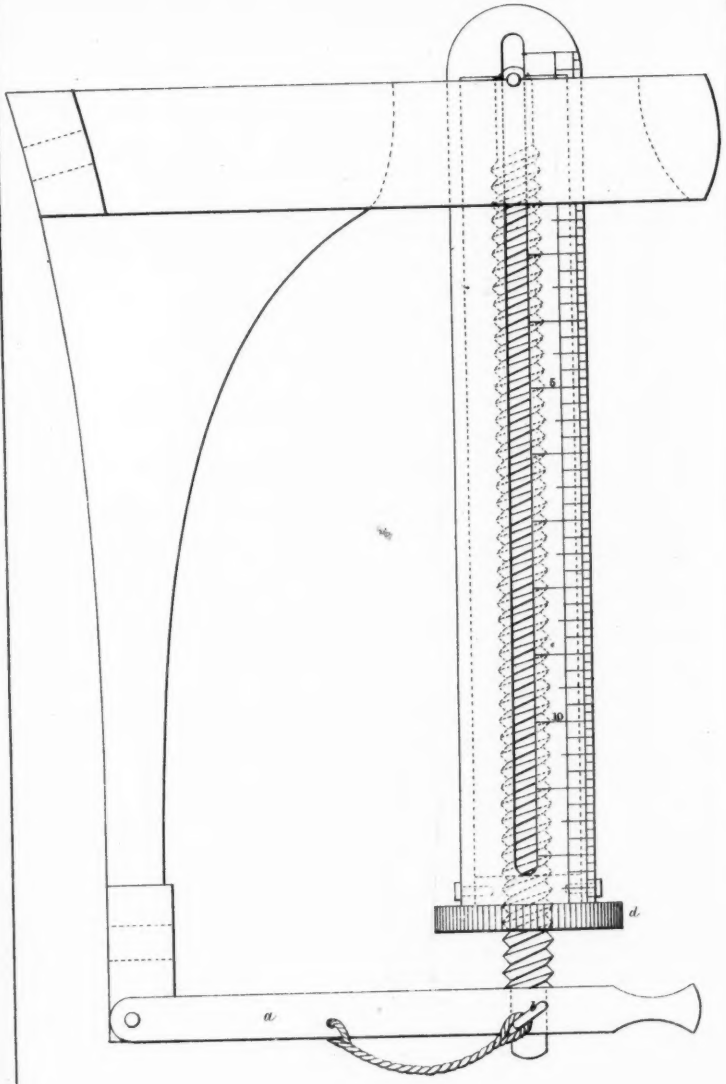
And then again, whenever rifled guns are used, the unfortunate seaman will have a distinct class of error to contend with, which will very seriously complicate his practice, for the error will have to be subtracted on the one side of the arc, while it is added on the other, and with the present means it is impossible to counteract this error, as a vernier for deflection on a fixed tangent-sight is an absurdity when a ship is inclining.

But the sources of error are not all enumerated; there will yet be the effect of the wind across the range, which will also cause a deviation of the shot to leeward of the object, and thereby add seriously to the "error of the bow gun," and when a ship is chasing under a press of canvas, and heeling over, say 10°, the force exerted by the wind will be very considerable. It is however quite unnecessary to attempt any estimate of the amount, as it is sufficient to show that "the error of the bow gun," will be very seriously increased by it.

In the hitherto vain endeavour to overcome these errors, it has been the practice on board our men-of-war to direct the guns at an imaginary point to windward of the object, as affording the only means of aiming at all; a correct aim must therefore be impossible, for what eye, however practised, could, at a distance of 3,150 yards, estimate with the slightest approach to correctness, a distance of 455 feet to windward of an object, and to increase the difficulty, the amount of deviation after having been calculated never continues the same, as it is constantly varying as the vessel rises and falls under the pressure of the wind and movement of the waves, and as the guns are trained.

The importance of remedying these fatal defects in the naval gun practice has been felt for years past, and many officers have given their attention to the subject, but hitherto without producing anything sufficiently practical to warrant its general adoption.

THE PERPENDICULAR SIGHT.



J.F.Jobbins

I trust however to show that the case is not hopeless, and that a sight has been produced, which while it can be used in the usual manner will prevent any errors arising from elevation, inclination, or training.

The sight is still a tangent-sight, but having the line of sight to the object (which line is assumed to be generally horizontal) as the radius, instead of the line of dispart as at present, and being kept constantly perpendicular to this radius by gravitation, it will always give the elevation in a vertical plane, and be independant of any motion in the ship; the bore of the gun which lies parallel with the line of dispart (one of the sides of this plane) will equally be independent of any inclination or motion of the vessel, for so long as it remains *parallel* with the line of dispart, it may be either under or over this line, or even rotate around it (if it were possible), and yet the precision of firing would remain unaffected, and if a shot were discharged it would always strike at the same distance from the object aimed at, as was the line of dispart from the centre of the bore, a shot would in fact always strike some part of a circle having this distance as a radius.

From what has already been said, it must appear evident, that if the tangent-scale can be retained in a vertical position, "the error of the bow gun" can no longer exist.

Plate IV represents a sight having this advantage, and called a "perpendicular tangent-sight," which, when confined by the moveable arm *a*, and pin *b*, can be used precisely as the common tangent-sights, being then, like them, a fixture, but whenever required for use as a "perpendicular sight" the pin is removed, and the arm dropping down, releases the sight, which swinging freely on jimbols, at once assumes a perpendicular position.

The sight is raised or lowered by a female screw, by which the elevation is given with great exactness, and to avoid any injury from the action of the gun's recoil on the sight, the inner surface of the brass circle is lined with Indian rubber.

A horizontal vernier for wind deflection might (if deemed requisite) be easily added, but such an appendage to the sight is not desirable in naval warfare, as from the continual changes in a ship's position, the wind is constantly varying in its effect upon the range, and such an addition would only be confusing to the seamen.

I may here remark that the horizontal vernier which has been supplied with the Armstrong guns to the navy most seriously complicates the "error of the bow gun," as, when attached to a fixed tangent-sight, it must, whenever a ship is inclining, either add to, or take from, the elevation of the gun.

I will now briefly touch upon another subject, closely connected with the aiming of great guns—namely, the proper adaptation of the ship to the guns she has to carry.

The armament of a man-of-war forms, or ought to form, the most important part of the ship's equipment, for such a vessel, if rightly viewed, is merely a battery rendered capable of rapid locomotion, the battery, and all that relates to its efficiency, must therefore be the

first consideration, and the vessel itself, and everything connected with it, should be so designed that the battery might produce its greatest effect, and this is unfortunately far from the case at the present moment; for a naval constructor, however able he may be, unless possessing a special knowledge of gunnery, cannot be aware of, and cannot therefore be fairly blamed for any of the deficiencies in the numerous requirements which this science demands, when practised in one of its most intricate forms on board a ship at sea.

It was strongly urged but a few years back, how much benefit would be derived if an intimate communication were established between the departments of construction and steam, but how far more pressing is an intimate relation between construction and, the primary object of the whole, gunnery.

A man-of-war, to be thoroughly efficient, must be designed for the guns she has to carry, and not the guns fitted and adapted to her as a mere after-consideration. At the present moment there are to be found vessels of the same class in the navy, carrying precisely the same description of guns, in which notwithstanding the greatest difference will be found even in points quite unconnected with anything relating to their sailing; taking for instance the extreme amount of depression a ship's ports will admit, the following return from eight line-of-battle ships which happened to be together at the same time, will show how great a variety exists even in this simple particular, and, singular enough, the smallest amount of depression is to be found in one of the crankest of the vessels, and the greatest in one of the stiffest, so little had one of the first requirements of gunnery to do with the designs.

$2\frac{3}{4}°$	to	4°	4°	to	$4\frac{1}{2}°$	$4\frac{3}{4}°$	5 to $5\frac{1}{4}$
$3\frac{1}{4}°$	to	$4\frac{1}{4}°$	$4\frac{1}{4}°$	to	$4\frac{1}{2}°$	5°	$5\frac{1}{2}$ to 6

It appears from this that only two of these eight sail of the line have the power of depressing the whole of the guns on the same deck to the same extent; but bad as is this difference in the amount of depression, the narrow limits in the depression observable throughout is far more serious, as it involves the question of a line-of-battle ship merging into a mere frigate on being deprived of a whole battery of her guns, for it is clear that, whenever a line-of-battle ship heels over more than she can elevate and depress her guns, she will be deprived of the use of them; and it will require but a moderate breeze to heel a ship 4° or 5°, when the greater part of these ships would be rendered incapable of firing their guns horizontally. Then, again, stress of weather will frequently oblige the lee-ports of a line-of-battle ship to be closed, and, if engaging from to windward, will thus convert her into a frigate, but as the weather ports can be kept open much longer than the lee, the line-of-battle ship may run to leeward of her opponent and engage with her weather guns, provided only (and this is the important point) that her ports will admit of a sufficient degree of depression, and which, with these eight line of battle-ships would not mostly assuredly be the case.

As regards the training of guns, the following extracts from the same return will also show how wide a difference exists, and these vessels may be taken as fair specimens of their class.

The angle formed with the course steered which each of these ships must luff up to, before their entire broadsides could be brought to bear on a vessel coming up astern, is here given—

63° 30′	69° 00′	65° 00′	63° 37′
60° 00′	90° 00′	61° 30′	64° 00′

This shows very distinctly the serious difference which exists in these ships, but whether on board iron-cased ships, or in the old specimens of our navy, the requirements of gunnery must always be based on invariable principles, and real efficiency can only be secured by these principles being carried out on a common system, and which cannot safely be neglected, as the aggressive power of our fleets becomes greatly circumscribed by a want of proper attention to these matters; as, for instance, how lamentable would be the exhibition, if, when about to engage on a line of bearing rendered necessary by the relative position of the contending fleets, it was found that only two of these eight sail could bring their broadsides to bear without changing their course, and which, when in close order of sailing, can never be done by particular ships without deranging the whole of the line.

On the other hand how very desirable it would be that the guns of a fleet should train, elevate, and depress alike, as a knowledge of the exact angle, at which all his guns could be brought to bear with the greatest effect, would give a Commander-in-Chief an incalculable advantage in commencing a general action, for he would then determine with precision the exact course to be steered, and thus avoid any unnecessary hauling up, or keeping away for only one or two vessels, and which might prove the means of losing him the action.

A wider arc for the elevation and depression will generally meet (so far as is possible) the case of vessels which are cranker than others, but the stiffness of a ship has nothing to do with the training, and this latter might easily be made identical in all vessels by a proper adaptation of their hulls.

There are other equally serious points which might be mentioned, such as the state of the guns abreast of the masts, which in many vessels cannot be trained at all without blowing away the lanyards of the rigging or chain plates, but it is unnecessary to dwell further on the subject, as sufficient has already been adduced to show the necessity which exists for a considerable change, and as the real efficiency of our navy is so greatly involved in the questions which have been brought forward, we may, I trust, hope that the time has arrived for a thorough revision of the present system of fitting and aiming the great guns, for there has never been a period in the history of our navy in which success will so entirely depend on the most exact gunnery as the present time; a ship and her opponent can now be made comparatively impregnable by armour-plating, but there will still be the heel of Achilles, and it must be sought for, in the

protruding muzzles of the guns themselves, and in hitting such small objects the greatest skill and nicest aim will be required.

It would be foreign to the present purpose to enter into a discussion of steam rams and other similar subjects, which must play a prominent part in future warfare, but so far as the guns are concerned they must be aimed at other guns, and when breaches through the ports have been effected, the work of destruction will have to be completed by shells, carcasses, molten iron, and other such missiles discharged through the openings; but what precision of fire, and attention to every mechanical aid will not this require? and unless there be considerable improvement, we may probably witness the spectacle of ships engaging for hours, and expending the whole of their ammunition without any adequate mutual injury.

But if our fleets are to engage in this comparatively harmless manner they will cease to form a protection to our coasts, as they will be powerless to prevent a large fleet of iron-plated ships throwing a body of troops on our shores.

But without pursuing these discursive questions, I may observe before bringing these remarks to a close, that the country ought to feel thankful that the revolution in the long-established old war traditions and prejudices of our officers and seamen, caused by the introduction of the present system of gunnery (and which at first met with so much discouragement and opposition), has not been postponed until the present time; this system which was successfully carried through by Sir Thomas Hastings has since become so assimilated with the habits of the seamen, that a greater prominence may now be safely given to the practice of taking aim under all the changing circumstances of motion at sea, than was practicable, or even desirable at first; nor was it then so highly necessary, for until the adoption of iron-plating, so much attention was not required in aiming at such minute objects as the muzzles of guns. But first-rate marksmen at sea are now indispensable, and such cannot be obtained until the last stage of instruction has been gone through on board a ship in motion.

Cognizant as I have been of the working of the naval gunnery system, and of the success which has attended it, I have no desire for it to be supposed that, either covertly or openly, I am advocating a change in the course of instruction as given on board the "Excellent." Whatever the officers and seamen are there taught is necessary to qualify them to be the instructors of others, and must be taught in harbour; but, in addition to the mechanical improvements I have been advocating, I do desire to see engrafted on the teaching of that establishment (as absolutely essential to the future success of our navy) an additional means of practising our seamen in taking aim at sea, feeling assured that the greatest benefit would not fail to arise if merely an old frigate divested of her masts were secured to powerful moorings in an exposed position in the neighbourhood of Portsmouth, so that drafts from all the ships in port might be sent in constant succession to practice firing with inclination and motion. A frigate moored like a light vessel, without her masts, and with but

little ballast, would be found lively enough, and might be inclined with ease to any extent by ballast-trucks on wheels, and with springs to her moorings she could be readily brought into the trough of the sea or across the set of the tide, so that motion to any extent might be easily secured; such a vessel should be kept for the sole purpose of practising the taking aim with motion, and every officer, petty officer, and able seaman in port—having first been perfected in his various drills—should be sent on board in successive drafts to go through a week or ten days of this practice.

The benefit arising from such a course of practical instruction (which no ship in commission has the power of affording) would probably be found so great as to tend to the establishment of similar vessels at each of our naval arsenals for the instruction of the crews of every vessel that arrived in port.

It may with truth be said, that, with the exception of some minor affairs with slavers, our navy, since the conclusion of the great war in 1815, has literally had no practice in naval warfare on the high seas, and yet it is on the high seas that England's supremacy will yet be maintained or lost.

We may now reasonably anticipate from the comparative immunity afforded by armour plating, that our foes will for the future no longer seek the protection of forts and batteries, and that engagements on the open sea will rather be the rule than the exception, but out at sea, nothing but the most skilful seamanship and gunnery will avail anything, and our ships will no longer have to contend with half-fitted vessels, hastily filled with undisciplined conscripts, as in the last great war, for we shall probably have for our opponents highly practised crews, whom we cannot advance a claim to despise.

The country is now entering a new epoch in its naval history, to which the experience of the past will afford but little guide; let us therefore earnestly hope, that no false confidence in our resources, or in ourselves, will lull us into that fatal sleep which closes the eyes to the necessity for keeping pace with the progressive advance which is daily taking place in everything around us. If we do, we shall assuredly find, that the hour will come when the mistake will have to be retrieved, by a fearful expenditure of blood, treasure and national pride.

It is, however, the present insufficient and faulty means for directing with accuracy the aim of the great guns on board Her Majesty's navy that I have been endeavouring, however imperfectly, to bring before you to-day, and I trust I may have succeeded in showing how serious are the existing errors in our naval gun practice, and how simple are the means by which that practice may be rendered as perfect as the best firing on shore.

I have now only to thank you for the kind attention you have bestowed on the remarks I have ventured to make on these most important national subjects.

Admiral Hope's Testimony on the merits of the Training Level.

I hereby certify, that an instrument invented by Mr. Sharpe, for ascertaining the inclination of a vessel at sea by means of quicksilver and spirit, is far superior to any instrument I have yet seen for that purpose, it being capable of being read off with the greatest and quickest motion to a great correctness. I had opportunities of noticing this in very bad weather on our passage home from Quebec.

(Signed) SACKETT HOPE.

Evening Meeting.

March 2nd, 1863.

Captain W. H. TYLER, R.E., in the Chair.

NAMES of MEMBERS who joined the Institution from 16th February to 2nd March.

LIFE.

Somerset, L. E. H., Captain R.N.

ANNUAL.

Osborne, J. J., Ensign 15th Regt.
Parkinson, J., Lieut. 57th Regt. 1*l.*
Rouse, R., Capt. 3rd Suffolk Rifle Vols. 1*l.*
McCrea, J. D., Captain R.N. 1*l.*
Price, T. E., Lieut. R.A. 1*l.*
Woodall, J. W., Capt. East and North York. Art. Mil. 1*l.*
Bravo, A., Captain 1st West India Regt. 1*l.*

A NEW SYSTEM OF THE APPLICATION OF IRON TO FORTS AND SHIPS.

By G. B. V. Arbuckle, Esq., late 57th Regiment.

Gentlemen—

I wish to preface the address I am about to make this evening with an account of the various experiments that have been made at different times with iron in plates and bars, to resist the penetration of shot and shell, as it is evident that, at this period, the science of attack and defence is undergoing a great change. Our war-ships are already cased in armour, and it is said that before many years our fortifications will be also.

This is a subject that has engaged the attention of many other nations, and, indeed, only a short period since, when the "Gloire" attracted so much notice, was the subject taken seriously in hand by our Government. Long previous to this (in 1854) specially constructed ships had been plated with 4½ inches of iron, but after the Crimean

war the subject was allowed to rest, until the French Emperor commenced the construction of an iron fleet, supposed to be invincible.

The first experiment of which we have any record, was made at Woolwich, thirty-three years ago, when bars of iron in two rows, one horizontal and one vertical, the former $1\frac{1}{4}$ inches square, the latter $1\frac{1}{2}$ inches, were fastened into a mass of granite, 5 feet high, and 7 feet thick. This compound mass was fired at by 24-pounders at 600 yards, and destroyed completely.

The next experiment with bars of iron took place in 1859, when the bars of iron were 10 feet long, $4\frac{1}{2}$ inches wide, and 14 inches deep. The difference in the amount of resistance thought to be requisite in the two cases is very remarkable: in the first $2\frac{3}{4}$ inches, in the second 14 inches. The iron was furnished by Messrs. Thorneycroft and Co., of Wolverhampton, who have favoured me with the following account of the experiment:—

The target was 10 feet long, $4\frac{1}{2}$ feet high, and 14 inches thick. Seven 68-pounders at 400 yards made slight indentations only. Wrought-iron shot chipped it slightly, they failed to break through, and the gun behind was protected.

This target stood no doubt remarkably well, and although the system was tried subsequently, it did not appear to answer so well; but the circumstances were very unfavourable. The bars were smaller, being 10 and 8 inches in thickness in place of 14, so that at the time guns were increasing in power, the targets were less strong—less able to resist. These are the only experiments that have as yet been made against bars, although we see every day accounts of plates from every manufacturer almost in the kingdom, and the result always the same—penetrated, broken, destroyed; while bars of iron, of great thickness, if well backed, "not unless," are positively impregnable.

One of the great objects of Government is this—to obtain a protection for guns that shall resist the destructive effects of shot; and to effect this two methods have been advocated—bars, as before-mentioned, and plates. Plating consists of two kinds: one where a total thickness is made up of many thin plates, the other where a mass of iron is rolled or hammered into one large plate, as those at present supplied to the Royal Navy.

Plating has been experimented on from $\frac{1}{4}$ of an inch in thickness up to 8 inches. In 1850, a target was made, composed of $\frac{5}{8}$-inch plates, representing a part of the "Simoom," an iron-built ship. It offered very slight resistance, and clearly showed its inutility as a war-ship: the shot and shell broke up, scattering fragments everywhere. Although $\frac{5}{8}$-inches broke up shot and shell, it was found that a less thickness did not do so, shot and shell passed through plates $\frac{1}{4}$ and $\frac{3}{8}$ inches in thickness without breaking.

In 1854, some experiments were carried on by the Admiralty at Portsmouth.

A target, composed of $4\frac{1}{2}$-inch plates, backed with fir-planking, the whole bolted to a strong timber framework, well braced and strutted, was fired at by 32-pounders at 360 yards—plates indented and

cracked. At 1,200 yards, the 68-pounder, with a charge of 16lbs., cracked the plates. and at 400 yards, destroyed target and backing.

In 1856, plates 4 inches thick, backed by 2 feet of woodwork, were furnished by different makers for experiments at Woolwich.

Cast-iron shot, at 400 yards, indented and cracked the plates, drove in the bolts, and shattered the backing. Wrought-iron shot, at the same range, went through.

In 1857, experiments were carried on against steel-plates, which were found quite unserviceable from their brittle nature.

In 1858, experiments were made at Portsmouth with a gun proposed by Mr. Whitworth, but the gun having burst, the only record of the experiment is, that at 450 yards, a wrought-iron shot went completely through the 4-inch plating.

In 1858, the "Erebus" and "Meteor" were fired at, at Portsmouth. The "Erebus" had a $\frac{5}{8}$ skin on iron ribs, 6 inches of oak planking, and 4-inch wrought-iron plates. The "Meteor" had an inner planking of oak from 4 to 9 inches, 10-inch oak timbers, 4 inches apart, 6 inches of outside oak planking, and 4-inch plates.

At 400 yards little damage was done to the latter, but the former was easily penetrated, showing, in the case of the "Meteor," the value of a good backing.

In this year also, a large wrought-iron plate, 6 feet by 6, and 8 inches thick, was fired at by 68-pounders at Woolwich, charge 16lbs., range 400 and 600 yards. Cast shot indented and cracked the plate, and wrought-iron shot broke it up. Previous to this, blocks of cast iron, 8 feet by 2, and $2\frac{1}{2}$ feet thick, backed by granite, were fired at by 68-pounders at 400 yards with solid cast-iron shot.

Wrought-iron shot broke off large fragments from 10lbs. to 80lbs.

Cast-iron shot broke up.

Wrought-iron shot recoiled, much flattened.

I wish that point to be remarked, that, against a solid mass of cast iron, the solid wrought-iron shot "*recoiled*," making only an indentation.

In 1859, a special committee was appointed to consider the subject. Plates, $1\frac{1}{2}$, 2, $2\frac{1}{2}$, and 3 inches in thickness, were made and bolted on to a target representing the side of a 50-gun ship, in fact, an oak backing from 18 to 24 inches thick. Steel and cast-iron solid shot passed quite through the plates and backing, the steel entering the cast iron, breaking it into fragments. Of the shells, two passed through the plates but not through the wood, and all broke up.

In 1859, the woodwork of the "Trusty," one of the ships used during the Russian war, being found rotten in many places, it was determined to convert her into a target. She was originally built for a floating battery of 40 guns, being plated with iron $4\frac{1}{2}$ inches thick, on 25-inch solid oak. At 400 yards the 80-pounder gun broke the plates but did not pierce. At 200 yards the cast-iron 100lb. shot did a great deal of injury, but did not penetrate. Homogeneous-iron shot punched a hole quite through the plate and 10 inches of timber remaining there: round shot, fired obliquely, did less damage than direct shot, and glanced off.

In 1860, the Jones's angulated target was tried. It consisted of an inner skin of iron, to which was fastened 13½ inches fir-planking; on this were fastened the armour-plates, placed at an angle of 52°. The armour was 4½ and 3½-inch steel, and 4½-inch wrought iron. Range, 200 yards. Result—the steel-plates were useless. Penetration declared to be less than half that on perpendicular plates. The effect on the *woodwork backing* very slight. I wish that to be *particularly remarked*, as it bears very much on the system which I wish to speak of.

In 1861, a Special Committee on Iron was appointed, their object being to consider the best manner of protecting our ships and fortifications, and the best form of applying the armour. Practical and scientific men were invited to attend, and the following plates were ordered from different factories:—

Homogeneous plates.
Hammered plates.
Rolled plates.
Steel plates.
Steel and iron combined.

As the plates were too thin, they yielded to the attack, and nothing satisfactory was elicited, except that it led to the trial of some other targets of greater strength by different inventors, Mr. Roberts, Mr. Fairbairn, Mr. Hawkshaw, an account of which trial may be interesting.

Mr. Roberts' target consisted of a mass of timber and T plates, protected by armour-plates 3 and 4 inches thick, rolled and hammered to present a series of angular projections (ridge and furrow), the apices of the angles pointed with steel.

Result.—Completely destroyed by 100-pounders and 68-pounders.

Mr. Fairbairn's target.—Plates 5 inches thick, attached by a number of screws to a ¾-inch skin supported by wrought-iron built-up ribs of ½-inch plate, 12 inches deep, 18 inches apart. The screws were 7½ inches apart.

Result.—The plates themselves stood well, but the screws all broke, and the armour fell off.

Mr. Hawkshaw's target consisted of a resisting thickness of 10⅛ inches, being composed of one 2-inch plate, and 13 plates ⅝ inch each, held together by alternate screws and rivets.

Result.—Penetrated easily, and it was found that a number of plates, as compared with one solid plate, are comparatively weak, as the shot acts upon each plate in detail, the resistance being as the square of the thickness. Thus, if one plate is 4 inches thick, and another 3, then the resistance is as 16 to 9. A 6-inch plate, therefore, as compared with 4-inch, would be as 36 to 16, supposing the plates to be of equal qualities, and all the circumstances the same; but this is *the great* difficulty, both for plates and guns, a large mass of wrought iron made into one piece, at a high temperature, which it must be to manufacture, is in an *expanded state*, when it cools, it contracts, and the result is almost invariably, in large masses, a hollow in the centre. I will record one more experiment against inclined plates. They were

tried up to 3 inches in thickness at angles of 30°, 45°, and 60°, and no apparent difference found in the power of resistance. *But* the plates were simply held on to a *skeleton framework without backing*, and *this is the cause of the failure*. It was clearly shown in the case of the "Erebus" and "Terror" that a good backing is most invaluable.

I now come to the most important experiment that has been made at Shoeburyness, viz., the trial of Captain Coles' shield. It may be said, important, because successful. The first experiment consisted of 18 shots from a 40-pounder gun at 200 yards. The shield was slightly indented. From the 18th round to the 65th round, the cupola was fired at by a 100-pounder Armstrong gun at 200 yards also. The result at the 55th round, penetration, *but*, the plate was a very bad one, and, nevertheless, only yielded to eight or ten shots, which had struck it at the same place. This shield then, composed of iron 4½ inches in thickness, with a wooden backing at an angle of about 40°, stood 50 rounds from 40-pounder and 100-pounder guns. The advantage was all on the side of the defence, and the result clearly proved that iron at an angle, if well backed, can resist any assault, for it is manifest, however large your gun may be, the iron can be increased in thickness to any amount in wedge-shaped bars mutually supporting each other, but not in plates.

It has been represented by an eminent engineer, that, for a fort, the arch system of iron would not answer, *because*, the velocity of a shot is such that it overcomes everything that opposes it The error of this argument is apparent, for if a shot is fired at a wall of iron sufficiently thick, we know perfectly well what must be the result; instead of the velocity overcoming the resistance, it is exactly the contrary, as was proved when wrought-iron shot were fired, in 1857, at a wall of cast iron 2½ feet thick, and were repelled. So, if the arch is sufficiently thick, it repels likewise.

The value of a curved and sloping surface has not been as yet sufficiently appreciated. With a perpendicular frontage (and with the experiments recorded in nearly all cases, the target has been at right angles to the trajectory) the whole force of a shot is expended *locally* on the part struck, whereas, with a curved surface, the force radiates in all directions, and is thereby much weakened.

To sum up the experiments then that have been made up to the present time—

1st. We have records of plates varying in thickness from 1 to 8 inches, and in one case, a wall of iron 2½ feet thick. The last case being the only one in which there was no penetration, as, of course, there could not be. In this case then the shot recoiled.

2nd. In the case of the "Trusty," shots glanced off.

3rd. In the case of the inclined target of Mr. Jones, round shot also glanced off, and the penetration was declared to be less than half that on perpendicular plates.

4th. Against the shield of Captain Coles the impression was almost nil, for, although the shield *was* penetrated, it was not till after 54 rounds had been fired at it; *that very number* proving its approximation to invulnerability under ordinary circumstances. It must not be

forgotten, too, that a little white spot was painted on a weak plate, and this could never happen in actual warfare; and that against the bars proposed by Messrs. Thorneycroft in the first experiment, the impression was slight; we may therefore conclude that a resisting mass *may* be obtained through which shot and shell shall fail to penetrate. It has been stated in the recorded experiments that plates at angles of 30°, 45° and 60° were penetrated, and it appeared there was no difference whether the plates were sloping or upright, *but*, it should be remarked, they were on a skeleton framework, and there was no backing. *In this* consists the whole theory of resistance, for, if it is desired to *break* a bar of iron, precisely the same course is taken, the ends are supported, leaving the middle *un*supported to receive the full force of the blow; in the case of its being laid on a flat surface, such as an anvil, the force of the blow passes through the iron, and is, in reality, received by the anvil underneath. So, in the case of the "Erebus" and "Terror," both were covered with iron plates of "*equal thickness*," but, in one case there was a strong backing, in the other a slight one. The former stood well while the latter was knocked to pieces.

Of the "Trusty" experiment at Shoeburyness, it may be said,—1st. That no target ever stood such a hammering at all. 2nd. That any other target would have been broken to pieces. 3rd. That the extraordinary invulnerability of the target was owing to every blow being received on an arched and sloping surface, that arch diminishing the force of the blow.

You are aware that in the olden times, a simple wall surrounding a town was considered sufficient to protect the inhabitants from attack. The invention of gunpowder rendered these walls useless, and the various systems of Vauban, Dufoure and Cormontaigne were adopted. It is said that these will soon be as obsolete as the old walls which were once thought so good; that before modern artillery they will all succumb speedily, unless faced with iron, or some plan be devised by which a hostile force shall be held at bay.

The latest siege of a fortress favours this view, and that you may judge for yourselves the importance of the question, I will read the description of it from the despatch of the officer commanding the assault. It is of such late occurrence, having taken place only last year, that at this moment, when *really* nothing definite has been decided, it will forcibly establish one point, viz., the speedy reduction of any escarp of brickwork; and, unless the escarps are strengthened, they will all crumble to pieces before the combined attack of the present ordnance, unless outworks can be devised which shall prevent a besieger establishing his batteries, or they are otherwise rendered impervious to attack by being plated with iron.

Account of the Siege of Fort Pulaski, in Georgia, during the months of February, March, and April, 1862.

The fort is described thus:—"It is situated on Cockspur Island, casemated on all sides, walls 7½ feet thick, command 25 feet, mounting one tier of guns *en-barbette*, and one in casemates, surrounded by a wet

ditch. The fort mounted 42 guns." From the date of its fall, a new era in the matter of breaching fortresses may be reckoned. For, in the ordinary works on Fortification hitherto published, it has been stated that a wall may be breached with certainty from a distance of 500 to 700 yards, and, in cases of great necessity, at 1,000.

This fort was reduced at a *distance of* 1,700 *yards.*

From experiments lately carried on in this country, it was found to be impossible to reduce a Martello tower with smooth-bores at 1,000 yards. With rifled guns at the same distance a breach was made.

The report of the officer commanding before the fort of Pulaski, states that the breaching batteries were established at a distance of 1,700 yards from the escarp walls. The walls being oblique to the line of fire, and 7½ feet thick, backed by heavy casemate-piers and arches, a practicable breach was made in less than 48 hours, at an expenditure of 2,400lbs. of metal per lineal foot. The average expenditure in Spain was 2,500lbs. per lineal foot, and the breaching batteries were at a third of the distance.

The guns used were rifles and smooth-bores combined, of the former 58 per cent., the latter 42, these being 68 and 128-pounders. The rifle-shot were used to pierce and crack the walls, the heavy smooth-bored shot to bring down in lumps the masses thus loosened.

Heavy mortars and heavier guns were brought into position, and it was afterwards found their services could have been dispensed with. Had this been known, seven weeks of most harassing and tedious duties could have been avoided, as the batteries were established at the termination of a causeway which had to be constructed of planks, on soft ground, with swamps on either side. Bringing up the guns was a work of the greatest difficulty, each heavy piece requiring 250 men, and the greatest caution was necessary to prevent its being overturned, in which case it must have been almost irretrievably lost. The saving of labour (amounting to two months) which might have been made, is worthy of remark, also, when the guns once opened fire, the remarkably business-like way in which a breach was made; the rifled guns being used to pierce and loosen, and the heavy smooth-bores to bring down the masses thus separated.

It may be presumed, then, that forts such as exist already, are doomed speedily to succumb if invested, and the besiegers are able to carry on the customary operations of a siege. But what would happen if the ground encircling a fort were already occupied; and if that occupation were of such a nature that it must be reduced before breaching batteries can be established? It is only in this iron age that such a thing could be done. The method proposed is this—"The Voussoir System" either at right angles to the horizon, or sloping. Including the forts already built, such as Portsmouth and Plymouth in this country, Fort William and Fort St. George in the East Indies, and in all situations where the ground will admit of it, and the supply of water is unlimited, to place small iron forts or towers, either to take breaching batteries *in reverse* or *enfilade.* These, to be of any avail, must be "impregnable themselves," if they *can* be so constructed. Let us consider that point then.

The accompanying diagram shows the method of making an iron parapet to resist shot.

Bars of iron, 14 to 20 inches in thickness, or more, two sides curved and two diverging, *vide* plate v, fig. 1, inclined to the horizon at an angle of 45°, resting on buttresses at an angle of 45° also, fig 2; the bars wedge-shaped, and dove-tailed in the rear on another set of bars, so that the whole presents a series of arches at an angle of 45°, supported by suitable backing, and outside each segment if requisite a 2 or 3-inch sheeting of iron, the ends overlapping so as to be hid in the interior. This, unless shot away bit by bit, would be a network of great value. The whole presents a resisting mass without any bolt-hole in it, and once having a parapet impregnable, small fortresses of iron, with revolving turrets or cupolas, would present a formidable obstacle; bomb-proof barracks would be constructed within. This is the principle; the detail may vary.

One of the American vessels, when boarded, presented no place of *admittance whatever* to the assailants except the embrasure, which was seen slowly to revolve. It is needless to add the boarders were glad to retreat. Works of this kind, therefore, could not be taken by escalade; judging from the recorded experiments, it may fairly be inferred that forts may be made thus to resist anything, as there is a limit to the gun *but not* to the strength of the arch.

Allowing, for the sake of argument, that it requires a thickness of iron of 20 inches to keep out shot, this is the only method, at this time, by which that thickness can be given, except at an *enormous cost*; the iron wedge-shaped bars here spoken of are produced at 17*l.* to 18*l.* per ton, the present cost-price of iron plates, such as are supplied daily to the navy, is from 40*l.* to 47*l.* per ton, and the thickness 4½ inches *only*. Each segment, as before stated, rests on a suitable backing, as well as the buttresses, except that part immediately in rear of the embrasure. Here we must have given the thickness of iron that will repel shot at an angle of 45°.

In all calculations, something *must* be given on which to found a theory, otherwise the whole is hypothesis.

The engineer who carries his railway up a mountain-side, like those lately constructed in Spain, must have given the power of his engine, and the weight of the load to be borne before he can adjust his incline. The physician who cures our complaint must have given either the cause of our illness, or our symptoms, ere he can prescribe. So, to build a fort and make it invulnerable, you must have given the weight of the projectile, and the velocity with which it will be propelled to make the defence proportional.

The strength of the arch prevents its being broken in, and the outside plating, as well as the interior fastening, prevents the iron rebounding outward from the force of concussion. The elasticity of iron is slight, and the weight of each part tends to keep it in position when once in its place. Allowing that the outside plating would be much broken unless it was altogether displaced piecemeal, the parts left would form a valuable network to hold all together.

The embrasure is undoubtedly a most difficult and delicate point to

Isometrical Elevation of Iron Parapets

A.B.A.B. are wedged shaped bars of iron at an angle of 45° supported by buttresses C.D. at the same angle.
e. e. e. e. Tenons mortised into the bars f. f.
Principle not the detail shown.

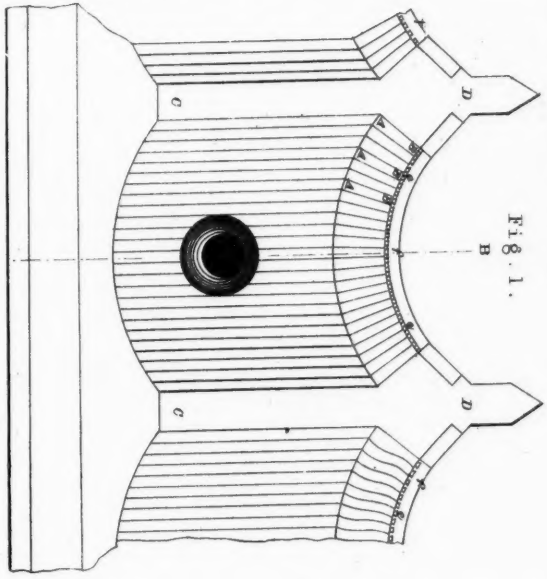
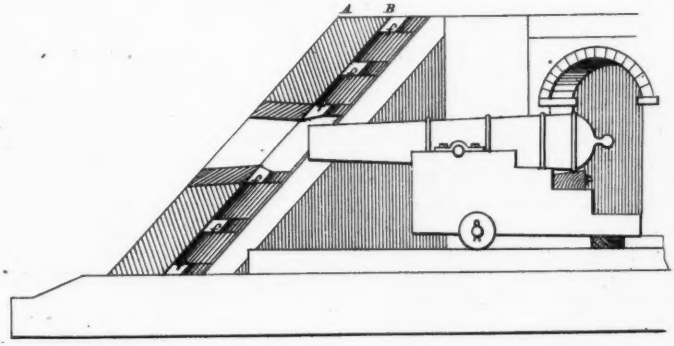


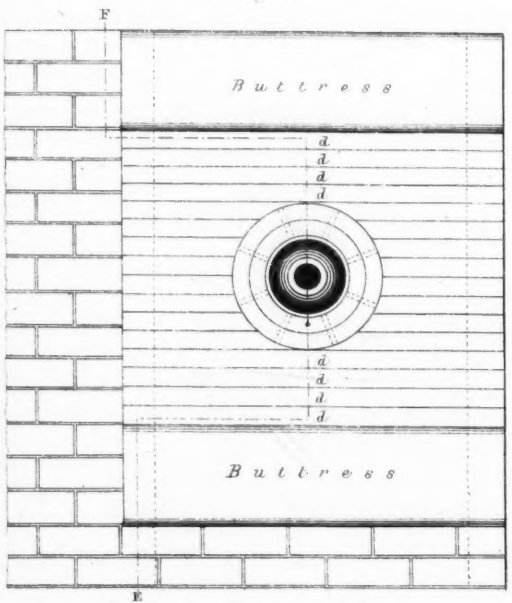
Fig. 2.

Taken on the Line A.B.



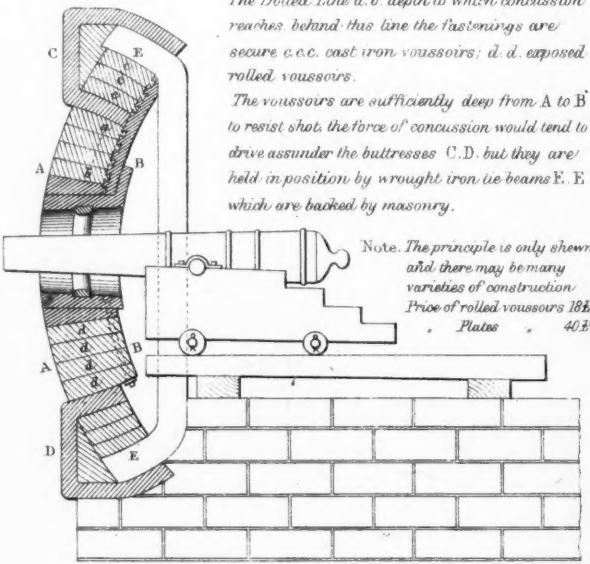
For the defence of Harbours, Mouths of Rivers.

Fig. 3.



Front Elevation.

Fig. 4.



Section on the Line E. F.

Explanation

The Dotted Line a. b. depth to which concussion reaches. behind this line the fastenings are secure. c.c.c. cast iron voussoirs; d. d. exposed rolled voussoirs.

The voussoirs are sufficiently deep from A to B to resist shot, the force of concussion would tend to drive assunder the buttresses C.D. but they are held in position by wrought iron tie beams E. E. which are backed by masonry.

Note. *The principle is only shewn and there may be many varieties of construction*

Price of rolled voussoirs 18£ per Ton

" Plates " 40£ " "

Impregnable at an Angle of 45°

Pl. VI.

J.R. Johnns.

settle, but if we have *given* the thickness of iron that will repel shot, probably the difficulty will be diminished. Until this is ascertained, it is impossible a satisfactory result can be arrived at.

Many experiments have been carried on at Shoeburyness, and the point is still undecided. The plan proposed may also be seen from the accompanying diagram, and the embrasure can be made of any resisting power.

The embrasure is made of concentric rings of iron, from 12 to 20 inches (or more) deep, each ring in itself is the hollow truncated segment of a cone, figs. 3, 4. The whole forms a massive, hollow segment of a cone; the depth of it must be sufficient to absorb a blow without dislocating the fastenings in the rear. By this method a solid resisting homogeneous mass of iron is presented. Bands of iron, also fastening in the rear, might be useful, as well as bolts let in, to prevent the rebound, and before one ring could be loosened, not one or two bands, but every band must be broken at the same distance from the centre to let it fly out: to protect these they are let in the rings so as to be flush with the surface. An embrasure of this description is said to be expensive. Doubtless it is so, but many expensive things are worth the amount demanded for them, and this probably is one, for the guns in a fortress must be defended at any price.

I will now proceed to make some remarks on artillery, and if I am in error, trust some gentleman will correct me, as this theatre is the only place I know of, where all branches of the service are invited to discuss professional matters, interesting to each member at home, and more so to those abroad who have not the opportunities we have either of witnessing the experiments or hearing the discussions. In a national point of view also they are important, as even now it is undecided whether the Spithead forts are to be built or not.

Let us consider then what is the immediate action of a shot impelled at high velocity? it either penetrates completely through the opposing substance, penetrates partly, or is repelled. If fired against a wall of iron of great thickness it is repelled, and the shot is much flattened; if fired against a thin wall of iron it penetrates completely. In one case pregnability, in the other impregnability. It follows then between the two there is a certain medium at which a shot would enter, and another where it would not enter. Let this be found, and by using a greater thickness you have comparative safety. And now with regard to ships. If it should be said that for ships so much weight could not be carried, then, *at all events*, let a ship be encircled at the water-line with such an impenetrable belt as would keep her afloat. Should plates not give it, one of Her Majesty's principal naval architects has informed us there would be no difficulty in applying the principle of the voussoir to ships, and from the actual results in the American war, we see clearly that a ship with one hole only at the water-line, sinks in fifteen minutes. *Vide* account of the action between the "Alabama" and the "Hatteras," when the large gun of the "Alabama" penetrated just below the water-line.

Between ships and forts I fear the former will have the worst of it

in any future naval engagement,* for on the deep there is a limit to the weight of armour,—not so on land. To prevent the destruction of a wooden ship by liquid iron shells, a very thin plating of iron, $\frac{1}{8}$th of an inch in the interior, would render them fire-proof, and if guns can penetrate the thickest armour which a ship will bear on her sides, the armour must be increased, at *any sacrifice*, about the line of flotation.

Of the guns about to be tried at Shoeburyness. I will mention one gun, the weight of which is 17 tons, weight of shot 400lbs. Suppose this gun penetrates through a mass of wrought iron 12 inches in thickness, say 20, and that you require 24 inches to afford perfect resistance, the arch principle is the only one that admits such a resisting thickness. If it should be said, take plates such as are now being made, and set them up edgeways, *then* there is a defect, for they are all parallel to one another, and one pushed through, dislocates the whole. In the arch this is obviated, as any force acts laterally, while in the former it acts locally.

It is in large works, more especially for the defence of your guns, that the principle is specially recommended, for this reason, you cannot get a homogeneous resisting front in any other way.

Having, then, an irresistible wall, which cannot be broken through, a bomb-proof barrack within renders the defenders perfectly safe. Any command desirable may be obtained by this method, and with revolving shields, which can be made impregnable on this system, the efforts of a besieger to establish himself would be a most hazardous undertaking, so much so, that he would probably decline the encounter.

The forts or towers should flank each other, with a glacis to render the foundations safe from attack, and a wet ditch as wide and deep as circumstances permit, fig. 5.

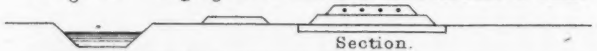
The expense of an iron fort for ten guns if compared with brickwork, will shew a very favourable comparison, *vide* fig. 5.

The southern coast of England is dotted in many places with Martello towers. These towers were each built for one gun on centre pivot traversing platform; the expense of one was 3,000*l.*, the expense of ten, therefore, would have been 30,000*l.* Now, the expense of an iron fort for ten guns, composed of iron 14 inches thick, would be very much less than the above, giving a lateral space of 17 feet to each gun.

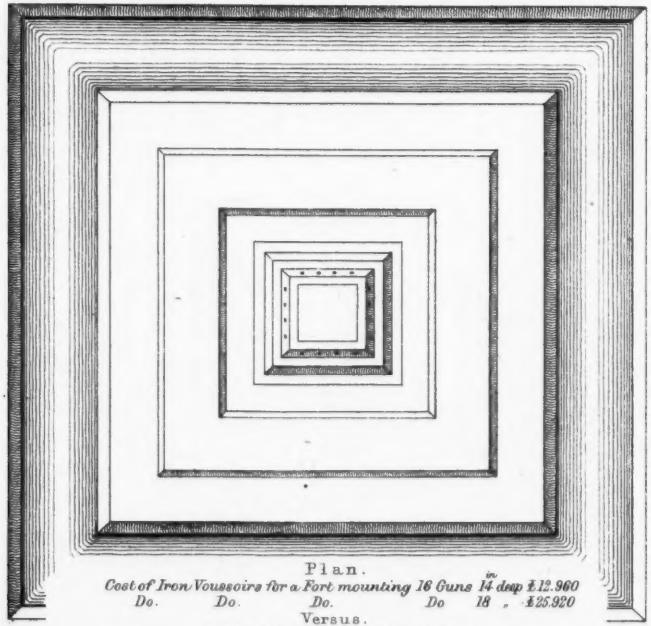
The extraordinary use that one or two guns may be of, on certain occasions, cannot be better illustrated than by two cases reported in Sir John Jones's *Sieges*, vol. 2. In one case, Sir Sidney Smith, with the "Pompei," an 80-gun ship, the "Hydra," 38 guns, and another frigate, anchored about 800 yards from a battery of 2 guns, on the extremity of Cape Licosa and protected from assault by a tower in which were 25 French soldiers, commanded by a Lieutenant. The line-of-battle ship and the frigates fired successive broadsides, till their ammunition was nearly expended, the battery continually replying

* Since this paper was read, March 2, 1863, accounts have reached this country of the attack on Charleston, and what was then stated has been actually verified.—G.B.V.A.

Fig. 5. Impregnable Bomb Proof Iron Fort for 16 Guns.



Section.



Plan.

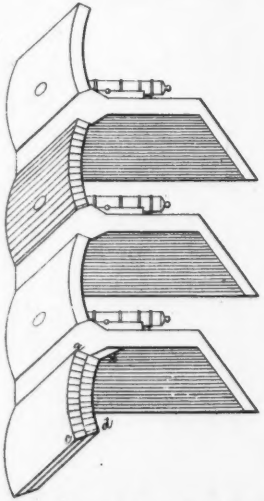
Cost of Iron Voussoirs for a Fort mounting 16 Guns 14 deep £12.960
Do. Do. Do. Do 18 " £25.920

Versus.

16 Martello Towers of Brick.. £48.000.

Isometrical Sketch.

a. b. c. d. represents a thickness of Parapet 28 in.ˢ obtained by one Arch resting on another; a mode of construction not obtainable by Plates



Cost of Iron Parapet 12 ft. by 12 ft. & 14 deep £576.
" " " " " 28 " £1090.

Pl. VII.

J.R. Jobbins

with a slow but destructive effect. The "Pompei," at which ship alone it directed its fire, had above 40 shot in her hull, a lieutenant, a midshipman, and 35 men killed and wounded. It afterwards appeared, that the carriage of one gun had failed on the second round, so that, in fact, the attack of an 80 gun ship and two frigates, had been resisted by a single gun. Another instance of one gun doing good service is related in the United Service Journal, No. 46. The small army that under Lord Lynedoch advanced towards Antwerp early in 1814, established a post on a head formed by the Polder Dyke, at some distance before Lille. The place is called Fort Frederick, though showing no appearance of fortification, beyond the barely visible site of two embrasures. From this post the French determined to dislodge them, and an 84-gun ship anchored at a distance of 600 yards for that purpose; the action lasted from 7 o'clock in the morning till 12 at noon, when the French ship hauled off, having lost 41 men killed and wounded.

Such, then, for defending our forts already built, is the plan proposed, viz., small impregnable outworks surrounded with water, wherever this can be obtained *ad libitum*. There is no reason to doubt the success of the defence. We have seen as in the case of Fort Pulaski only last year, that by the combined use of rifled and smooth-bore guns, an effective breach can be accomplished in less than 48 hours, in escarps of masonry, and this, too, at a distance hitherto thought impossible. *Yet* the longest range must be a known, a "*given*" distance, and by placing these little forts, as at Fort Lille, showing no appearance of fortification beyond the barely visible site of the towers or embrasures; by placing these forts, then, at *a greater than* breaching distance, they would render the investment of our fortresses, now existing, such a hazardous operation, that, until they were silenced, no investment could take place; the saving, too, would be enormous, as the escarp walls only of one fortress could not be iron-plated at a much less cost than a million. If not travelling beyond my *crepidam*, I should wish to say a few more words as to ships. The Premier, in a debate only last week, spoke of the necessity of having, as speedily as possible, an impregnable iron fleet. But haste may not be speed in this case, and it may be asked, are we not building fast without enquiring what the future effects of large ordnance are to be? Are we not building fast simply because the French Emperor set us the example some time ago?

Owing to the exertions of this excellent Institution, or rather to the officers who take great interest in it, is it not now tacitly admitted, that an expense of three or four millions has failed to produce a good naval gun, and that the rifled gun, as supplied to Her Majesty's ships, will not bear a large charge of powder, that, contrary to the opinions of naval officers generally, the value of smooth-bored guns with high velocity has been ignored, and the preference sought to be given (but repudiated by the navy) to long range.

It was stated also, lately, in the House of Commons, that ships MUST henceforward be strongly plated; that to send our sailors to sea in wooden ships would be little better than sending them to slaughter; *but* if the iron ships can be penetrated, and sunk with facility, in what

condition are they better than wooden ships only? indeed, if they can be penetrated at all at the water line, they are far worse, as the orifice made in a wooden ship *can* be plugged, in an iron ship it *cannot.*

It behoves us to proceed with the utmost caution. Our cousins across the water can take a much more dispassionate view of these matters than ourselves, and I will read an extract from the Report presented to President Lincoln, by the chief of the Ordnance Bureau in America.

Report to the President of the American Republic by the Chief of the Ordnance Bureau—selected paragraphs.

The constant and very natural solicitude manifested by the public in the changes which have been and continue to be made in the construction and armament of our ships of war, may warrant a more extended notice of technical details than might otherwise find a place in documents of this nature.

And yet, no definite conclusion has been arrived at in regard to either of these important problems.

Indeed, the most casual observer can hardly fail to perceive, that neither of them has advanced beyond the first proposition. And both are so unavoidably interwoven, that it is impossible to treat or consider either independently of the other, or to form any reliable opinon as to their future course or final shape. They represent, in fact, the competitive progress of attack and defence.

The Report then touches on the subject of their own guns, and alludes to the Russian war, the floating batteries at Kinburn, and states—

Peace was soon after declared between the belligerents, and very little attention seems to have been paid to iron-clad ships for two or three years, until the French produced the "Gloire," one of great power, which was followed by a sensation and action in England, highly appreciative of the possible consequences of being too slow in acting on the hint. Of course, there were various opiniohs as to the capacity of this formidable craft.

The British Government very wisely, however, decided not to lose time in constructing similar vessels, and has since followed the decision with a remarkable celerity, quite regardless of expense.

On February 25, 1859, the First Lord of the Admiralty announced to Parliament the policy of the Government in this respect; and the construction was begun of an iron-clad frigate to surpass the "Gloire." This ship has been completed, and is well known as the "Warrior," others soon followed in France and England, and armoured ships are, it seems by common consent, to constitute the main force of all navies. Every variety of opinion is expressed as to the proper material and construction of such vessels; and the British Government, not feeling at liberty to wait until results have decided, are compelled to make use of whatever seems most plausible for the time; and thus we are astonished by the most gigantic and costly experiments the world ever saw.

Notwithstanding the earnest and long-continued course of investigation which has been carried on by the governments interested; so little is yet known of the effect of ordnance and the resistance of iron plates in different forms, that the ablest and most experienced cannot agree in the armour best calculated to resist, or the ordnance to be used in the attack.

The mode of armouring also demands attention, and no remedy has yet been found to prevent the fracture of bolts and nuts.

At Shoeburyness, experiments seemed to prove the invincibility of the "Warrior" target, and a series of experiments were made. At one time the defence seemed to have the advantage, at another the attack. Sir Wm. Armstrong's 300-pounder gun promised great things, but burst at the fourth round; the rupture of this gun left

the way open to other competitors, and a long-neglected piece that had lain remote for years, was allowed an opportunity to try its powers. This was the Horsfall gun, its first blow was decisive. The plate 4½-inch was pierced and badly injured, and the gun quite unharmed. And to complete the entire failure of the defence, Mr. Whitworth drove a shell through the same target ("Warrior"). So that the system of armour that had been relied on, as affording perfect protection, proved vulnerable by shell as well as shot.

The ease and impunity with which one invulnerable ship can enter a port not specially prepared for such a visitor, and commit havoc at pleasure, suggest the policy of providing, by timely measures, against the possibility of damage to the immense resources thus exposed.

No method is suggested, but the report proceeds to state—

So far as opinion can be formed from experiments recorded, we are led to conclude, that those who, from their distinguished abilities and opportunities of investigation, should be the best able to form an opinion, have arrived at no final decision in regard to any of the essential points of the problem.

As the question now stands, the inference may be drawn, that forts may be impervious to attack, ships not so; in one case the weight of iron is of little moment, in the other of the utmost importance. The old proverb states, "A small leak will sink a great ship;" and as regards haste in building our "Warriors," &c., surely had the Committee which sat some time ago, and made its report May, 1862, been more numerously composed, and taken more voluminous evidence, their statements would not have been contradicted, as they have been, by an officer of artillery of known ability and science, nor would they have made hypothetical statements about the velocity of the 600-pr. and other guns, which guns, however, *are not yet made.*

Possibly, too, a gun that was *then* made, and the largest gun that has been proved in this country at this date might have been tried, and if so, it would *then* have been found true, as it has been since, that this gun would have penetrated the "Warrior," and all ships of her class, (and much stronger), with the greatest facility, and if it penetrated, under the water line, it would sink them to a certainty.*

Guns of this description, if rifled on the plan strongly advocated by Captain Fishbourne and Captain Selwyn, would then combine the advantages of long range and precision, with those of high initial velocity and great smashing effect—so requisite in a naval gun, which, indeed, naval officers declare to be the first necessity. The accompanying formula shows the amount of water that flows through an orifice 13 inches in diameter, at one foot from the surface.

The velocity varies per second, as the square root of the depth of the orifice below the surface of the water.

If the depth below the surface is one foot,

$$v = \sqrt{2gh}$$
$$= \sqrt{2+32{\cdot}2+1} = 8 \text{ feet per second.}$$

* Having predicted with accuracy the fate of ships attacking forts, I may be excused giving an opinion on the present iron-clad men-of-war; viz., that they will be no match for an impregnable gun-boat of superior speed with one 300-pounder. The gun-boat would sink them all in detail in a fair open fight with plenty of sea-room.—G.B.V.A.

The number of square inches in an orifice 13 inches in diameter is = 132·732.

Therefore in one second the cubic inches of water flowing through the side of a ship with one orifice will, if 13 inches in diameter, be $132{\cdot}732 \times (8 \times 12) = 12742$ cubic inches, and 277·274 cubic inches = one gallon.

Therefore, the number of gallons flowing in per second will be 46
= 2760 gallons per minute
= 27,600! in ten minutes.

But in consequence of the tearing effect of shot through a massive substance like iron, the wound is much larger than 13 inches in diameter, and, instead of 27,600 gallons of water pouring in, the amount would be in most cases more than double.

At two feet below the water line,

$v = \sqrt{2 \times 32{\cdot}2 \times 2} = \sqrt{128{\cdot}8} = 11$ feet per second nearly.

This gives 37,800 gallons in ten minutes; but, as before stated, the amount is in reality much more. If double, it would be—
= 75,600 gallons, and two such
wounds = 151,200 gallons.

It may be judged from this how long a ship would float with only one such opening.*

It may be said ships won't carry these guns. I have been in communication with one of Her Majesty's principal naval architects, who assures me, there would be no difficulty whatever in constructing a vessel to carry these guns, and with great speed. Would it not be advisable, then, to build vessels of this class of great speed and invulnerable, that is to say, rather than a large vessel with a number of guns, a small vessel with one gun. The large ship *cannot* carry armour (except on Mr. Scott Russell's plan, ships from 12,000 to 20,000 tons). The small ship with one gun (300-pounder) can do so. The ship's buoyancy, which is her life, *must* be the first care of the architect. If it is just to judge of the future by the history of the past, the days of the "Warrior" and ships of her class (although some are only now building) are already gone by.

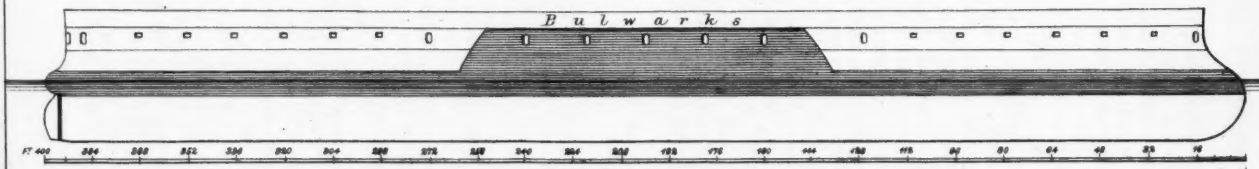
Commander Scott, R.N., has designed a vessel of the above description, to carry six guns, now under consideration of the Admiralty (plate viii, fig. 2); it is said, too, the Emperor of the French taking advantage of the experience in the American waters, is diverting his attention rather to small vessels with few and heavy guns, than to large vessels with many and smaller guns, vessels of *great speed*, and carrying enormous ordnance.

The size of the gun is of vast importance, more than is generally

* A ship not plated at all has this advantage, the holes are easily plugged up. Lately, firing at a target of wood with a very good rifle at 500 yards, I was surprised at hearing no sound, and concluded that every shot (20) had missed. On going up to the target no daylight could be seen through, which confirmed the original impression, but on going behind the target, which was on sloping ground, the earth was very much ploughed up, and, on a closer examination, I found that every shot had gone through the target (diameter of bullet ·451), and the wood closed up again. The target was one and in some parts two inches in thickness.—G.B.V.A.

Fig. 1. Side Elevation of Frigate 6.600 Tons.

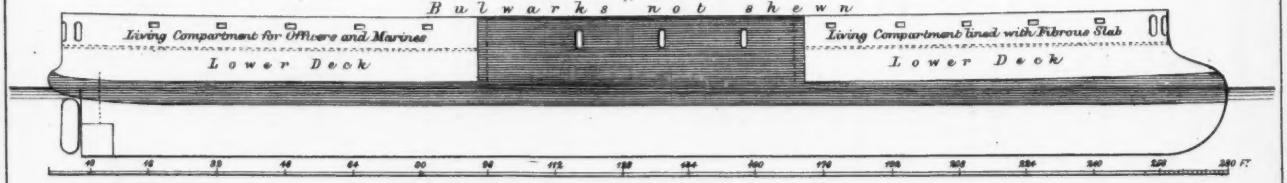
Breadth 60 Feet.



This Vessel mounts 10 Horsfall Guns 300 Pr.s 8 Light long rifled Guns, and 4 Light Howitzers in a fixed central Turret — Mean Draught of Water 21 feet.

Fig. 2. Side Elevation of Decked Corvette of 2.600 Tons.

Breadth 58. Feet.



This Vessel carries 6 Heavy rifled Guns firing smooth bore Ammunition, The Upper Iron Deck in the centre and the Lower Deck at the two extremities form a bomb proof protection against vertical fire. — Mean Draught of Water 17 feet.
4 Light rifled Guns are carried as Bow and Stern Chasers.

J.R.Jobbins.

assigned to it, and for this reason,—twenty guns, each a 1-pounder, are fired at a target of iron 1½-inch thick and produce no effect; one gun, a 20-pounder, is fired and smashes it, the velocity in both cases being equal—in both cases the same amount of metal is used, and on this principle an official record of experiments at Portsmouth states that one 68-pounder produced more destruction than 5 32-pounders. Arguing from this, it appears then 1 150-pounder is more effective than 10 68-pounders, 1 330-pounder is equal to 7 150-pounders, and a broadside of 3 330-pounder guns is more destructive than 10½ "Warriors." This result is very extraordinary and of the greatest consequence. The vessel proposed and approved of by many naval men, is of 4,600 tons, draught of water 21 feet, and carries 6 guns, each a 330-pounder.

A gun of this description has already been tried and found to answer, and for home defence it would be invaluable. When the gun was tried it was under the greatest disadvantages. The dispart was made of wood for the occasion, and a want of accuracy was assigned to it, but it is well known that up *to* 600 *yards our smooth-bore guns are quite as accurate as they are desired to be by the Royal Navy.* A ship then with very few guns, and fitted with Captain Symonds' twin screw-propellers, which enables a vessel to turn on her own axis instead of making the circle, would be a most formidable assailant. To show what a ship with one large gun can do, I will read an extract from the *New York Herald* of last year:—

From "New York Herald."

(Extract.)

The "Merrimac," fitted up by the rebels under many disadvantages, one day put out from Norfolk, ran by a fort of 20 guns, steering head on to the "Cumberland," 22 guns, crushing in her sides as if they were pasteboard, sending her to the bottom; in fifteen minutes fires into, captures, and burns the "Congress," 50 guns, riddles the "Minnesota," 40 guns; holds at bay the "St. Lawrence," 50 guns, and the "Roanoake," 40 guns; scares off a fleet of gun-boats, and, but for the "Monitor's" sudden appearance, the northern flag would have disappeared in those waters.

This, gentlemen, is the effect of one impregnable vessel carrying 2 guns, and can we doubt what would be the effect of one vessel, carrying 2 guns only of enormous power, among a fleet of "Warriors" and "Royal Oaks."

Experience has lately proved beyond a doubt that all the iron plates now in use by Her Majesty's navy can be pierced, and mathematical truth also clearly proves that with one hole of 13 inches diameter in a ship's side just under the line of flotation, water pours in at the rate of 17 tons a minute. The inference therefore may be drawn that vessels of the "Warrior" class (easily penetrable) are no match whatever for a gun-boat with one formidable gun, better protected and of greater speed.

On looking at the distant colonies of England, it appears that they vary in distance from 5,000 to 20,000 miles, and may be represented by voyages lasting from two or three weeks to two or three months. Of what use would our large expensive iron steam-ships be for their

protection, for as they can only carry coals for nine days, so they are only steamers for nine days, save when coals are to be obtained. Nelson chased the French fleet for 600 leagues 27 days, before he had the pleasure of seeing them at anchor. Is it not true that steamers would have shortened his voyage very little?

A leading article in the *Times* newspaper, when the accounts of the Merrimac reached this country, stated that after an expediture to be reckoned by millions, England had only *one* ship. This is a most grave error, for beyond the channels our wooden walls are good still; but if it was not so and we should have opposed to us 100 ships of the "Gloire" class, they would be no match for vessels with fine lines, and few guns, smooth-bored and large.

Has it not been proved that shot and shell can penetrate the armour at present in use; if so, of what use is it?

We see the effects across the water; an iron vessel is penetrated, and sinks to a certainty. It may be a hazardous remark to make, but I believe a wooden ship (if lightly plated in the inside to prevent fire) is preferable to a ship with armour, if that armour is not shot and shell proof, for the holes in a wooden ship can be plugged up. The orifice made in wood is much less than the diameter of the ball which enters. In an iron ship the orifice is not only much greater, but tears and breaks the surrounding iron. It is to be feared the American view of the state of the case is the correct one—viz., "the British Government, not feeling at liberty to wait until results have decided are compelled to make use of whatever seems most plausible for the time;" and, "those who from their distinguished abilities and opportunities of investigation should be the best able to form an opinion, have arrived at no final decision in regard to any of the essential points of the problem."

Surely the nation would gain by the formation of a Parliamentary Council to investigate the state of the question as it now is, to examine and to act—as the Article of War has it—without partiality, favour, or affection, or, for the defence of the kingdom, to confide in the wisdom of the Royal Engineers, a distinguished corps that has never failed in any duty assigned to it. The voice of the nation is certainly not against a large outlay; the only conditions being that the money voted shall be judiciously spent, the attack and defence being as perfect as each can be. It is related by Louis Napoleon that the English lost the whole of Normandy in *one* year A.D. 1450 in consequence of their neglecting the improved methods of defence, which of course are equally available for the attack, and which the French used. I wish to remark particularly the word *improved*. From it we may gather that they had defences, and thought them good enough, until fatally roused from their dream by defeat.

It is unbecoming in this great country, that an alarm, a panic *should* ever arise; besides being unbecoming, it is expensive, both to the nation and to individuals. The last panic called forth our noble National Guard. From its first enrolment in a few months, Her Majesty reviewed 20,000 men, suddenly made soldiers of the very first order, in Hyde Park. Peer and peasant alike came forward, and no

doubt it was a glorious sight, but the expenses attendant on the movement were not slight; the public and private expenditure being little less than two millions.

The time has gone by when any nation or combination of nations could conquer Great Britain, but the time has not gone by when the attempt might be made, and it is to guard against this that not I, who simply narrate facts, but the late illustrious Duke of Wellington, so often and so emphatically urged that England should ever be prepared to resist attack, and that the best method to ensure peace was always to be prepared for war.

The CHAIRMAN asked Captain Scott to explain various diagrams on the walls.

Commander SCOTT, R.N.: I wish to show by these tables which Captain Arbuckle has just referred to, not only the superior power gained by using very heavy shot, but also to prove that it is both very economical as to cost, and effects a very great saving in weight, and in the relative number of men required to work the guns. The table commences with the result of an experiment which took place at Portsmouth, when it was found that one 68-pounder fired against a 4½-inch plate produced a greater effect than five 32-pounders. And when it is remembered that the 68-pounder was fired with 16lb. of powder and one 68lb. shot, at a cost of only 17*s.*, and was worked by seventeen men, and that it produced a greater effect than the five 32-pounders which discharged 50lb. of powder and 160lb. of shot, costing 2*l.* 1*s.*, and worked by sixty-five men, there is evidently a very great advantage on the side of the large gun. But as we go on increasing the size of the gun, so we get a much more striking difference between the work done and expense incurred in using very large and comparatively small ordnance. For instance, ten 68-pounders are only equal to one 150-pounder, such a gun as that which was lately used at Shoeburyness, viz., the late Armstrong gun, called improperly a 300-pounder, though it fired only round balls, which were 150lb. when of cast iron, and 156lb. when of wrought iron; the wrought iron being the heavier metal. These ten 68-pounder discharges cost 7*l.*, and required 170 men, while the 150-pounder, which costs only 1*l.* 13*s.* for the powder and shot, could be worked on board ship with sixteen men. I compiled this table with a great deal of care upon the data before-mentioned, and I have examined very carefully the effect produced upon targets by the Whitworth and other heavy shot, and I do think they very nearly correspond with this tabular statement. As respects the effect produced by shot, there seems to have been omitted in all calculations the local effect produced upon targets by the heavy shot, viz.: that the target itself is driven back, and the fastenings which support it destroyed. Now consider what would have been the case if the target fired at had been part of a ship. I believe that then the part hit would have been driven away from the bottom of the ship; for the shock from the blow is so great; that it would almost inevitably destroy the ship. Captain Arbuckle has, if he will allow me to say so, made a mistake as to the size of the hole made in a four-and-a-half-inch plate, and backing of the Warrior target by the 284lb. shot from the Horsfall gun. I have no doubt he has copied his diagram from a very beautiful photograph which I have seen, mistaking the dimensions; but the hole, instead of being 13½ inches as shown in his figure across, is in reality 23 inches, an aperture which was described by the Americans, "as a hole as big as the head of a barrel." If the shot which made this hole had not been of cast iron, and therefore been broken up by striking on the plate outside, it would probably have also gone through another target beyond, in which the pieces were found buried. I do not propose to work these heavy guns in the way in which we work our present broadside guns; nor do I intend to work them by hydraulic power, or by anything beyond such simple mechanical means as sailors are already accustomed to. The method I would propose is to have a block with a single whip upon the side of each gun, to be led through a block at the side, and over a winch, such as we constantly have to use on board a steamer, to run the gun out. In the same way I deal with the recoil which is very difficult indeed, to take up, in the usual plan of train-tackles with a ship

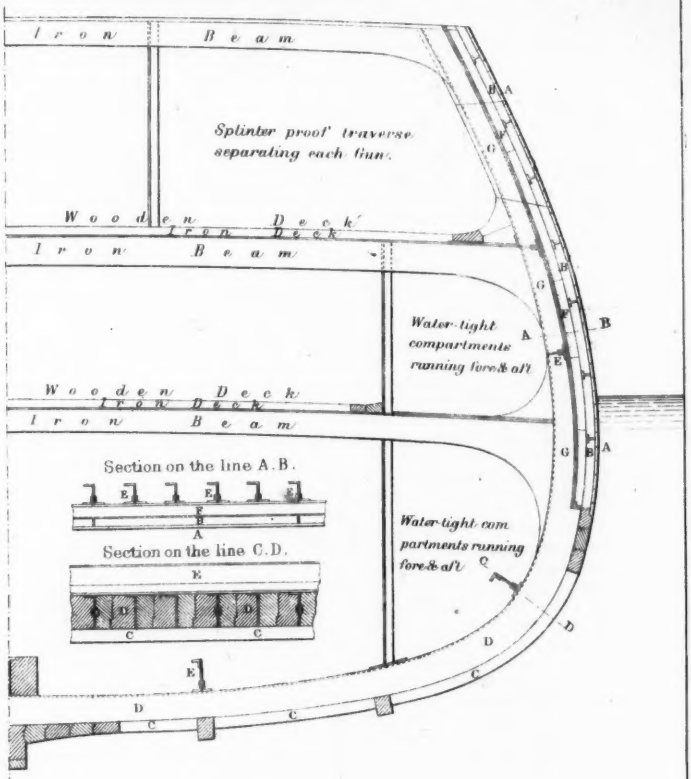
rolling; indeed, I cannot but express myself much surprised to see so little done towards winding *up the train-tackle quickly*, and working the guns easily, for at present there is a long train-tackle, and at the end of it a man or two, who cannot do the work fast enough. But supposing there was to be a single whip, and led through a block hooked on the rear of the gun-carriage, and then led over a large drum to take up as rapidly as possible on the gun's recoil, the slack of the train-tackle, then a great advantage would be gained. But I would not trust to the train-tackle alone with these heavy guns, it would not be sufficient. The great thing, however, which is required in ships to work these heavy guns, is space, and if properly handled, a big gun is as safe on a ship's deck as in any cupola; and has the advantage of more room. But there is more still wanted in working a very heavy gun; for it would not be safe to trust to the side-tackles any more than to a single train-tackle. It is intended that the gun should run on a slide, firmly held by pivots. On the slide there should be an arrangement to hold the gun, after recoil, but not to check it too suddenly; this could be effected by a kind of paul, on a plan which I hope to carry out some day. In case of anything going, or tackles being shot away, the gun would be stopped by the slide, which is sufficiently strong to hold the gun in any part of its passage out. Contrary to the usual way in which we work guns on board ship, I should place this long slide on rollers, which should both support and hold it firmly to the deck, and would use luff-tackles or the present gun-tackles for training, in the traverses proposed by me; that is, to put between every pair of guns a thin iron partition, so that on a shell coming into a port and bursting, its effects would be entirely local; for the traverses would prevent the pieces from spreading fore and aft through the ship, and hence the damage would be confined to the gun's crew. But these traverses are of further use: they bind the deck on which the gun rests to the upper deck. Nor is that their last use, as the tackles for training the guns are made fast to them, so that instead of being worked at the usual sharp angle, the gun would be very easily pointed by being pulled at right angles. Now I think I have sufficiently gone into the plan to show that large guns can be worked with few men, with two men at each side to man the winches, and two men to take up the recoil by means of the train-rope over a large drum, besides the first and second captain, loaders, and spongers. There are other arrangements, so that if anything be shot away, it can at once be replaced; but I need not go into these, for you will see that not more than sixteen men are required to work any of the heavy guns given in the table; that number is ample, as the training and also the loading is very easily done. But I will now turn to the manœuvring and say, that our present mode of turning ships by a single screw, will never answer for vessels in action, for it will not turn them fast enough. There is no doubt they could be butted by rams, and otherwise damaged by quickly turning vessels, and I therefore think we are very much indebted to Captain Symonds for bringing forward the twin screws, which afford the best way for turning our war vessels rapidly. It must not, however, be supposed from this observation, that our present ships with one screw cannot be arranged so as to be easily turned. What we want for this purpose is an auxiliary screw upon each quarter, and worked by a donkey engine, the screw giving a sort of pushing motion, and then feathering in to the side. Such a motion might be very easily given, and it would be sufficient to turn the vessel in action. I cannot say it is so good as the twin screws, because the motion of the twin screws must give greater stability to the ship. With one screw amidships, you could not keep a vessel nearly so steady as with one on each side; their motion tends to keep the vessel on a steady balance; for all of us who have been much on steamers know that directly the screw or paddle is stopped, the ship begins to roll tremendously.

I will not go into the question of the comparative advantages of working very heavy guns in cupolas and on the broadside, for I intend to touch upon it when Captain Coles brings his cupolas forward, and then I purpose stating what others as well as myself deem to be objections to the cupola, and therefore I think ought to be fully and fairly stated; but if Captain Coles can make out a good case, then we must have cupolas.

I wish now to point out some advantages to be derived from the use of the thick iron wedge proposed to be used in lieu of the comparatively thin and broad plates.

Mid-ship Section of Decked Corvette.

Designed in the early part of 1862 by Commander Scott and laid before the Admiralty Dec.r 1862.



Explanation of outside Construction.

A.A.A. *Wood Planking outside of Fibrous Slab.*
B.B.B. *Buffer of 6in Fibrous Slab breaking joint with the Armour Plates bolted through the corners.*
C.C.C. *Wooden Planking coppered outside.*
D.D.D. *Wooden Timbers bolted through Wood & Iron.*
E.E.E. *Strengthening Plates.*
F.F.F. *Armour Plates.*
G.G.G. *Iron Ribs.*

Scale 1/8 of an Inch to a Foot.

Frigate Designed in the early part of 1862.

J R Jobbins

Captain Arbuckle, some time since, showed me his wedge principle as applied to forts. The pieces are of course narrower on the inside than on the outside, they are all wedge-shaped. I have observed, that all plates seem to deteriorate by concussion or vibration, and to deteriorate very rapidly when struck by heavy shot. For instance, if a plate be placed on the side of a vessel and fired at by a 68-pounder, at the first shot it may exhibit a remarkable amount of toughness; at the second shot it will show less toughness; at the third shot it will be brittle; and at the fourth or fifth break in pieces. This rapid change does not occur at Shoeburyness, because you have another condition, viz., the plates being put more closely against a firmer backing, and the firmer the backing the better is it able to conduct off the blow from the plate. But in the case of the target ship at Portsmouth, you have a comparatively weak wooden side, not nearly so rigid as the backing of a Shoeburyness target, hence the plate is destroyed much more rapidly. We learn two or three important things from this. In the first place, that wood alone is not sufficiently tough and rigid for a backing to the plates; and it is a fact, that wood is only valuable in so far as it is supported by the iron-skin, which is of course capable of supporting a very heavy strain. It is stretched out and fastened to the ribs so as to yield the greatest strength of which the wrought iron is capable. The strain brought upon it by the blow of the shot is "tensile," and the wood only performs the part of distributing the force of the blow over a larger portion of the inner skin, and does nothing else. But if instead of the 18 inches of teak, which keeps the plates so far off the side that they must soon work loose, about six inches of paste-board, mill-board, or some other tough material were used, no splitting would take place, and the blow of the shot would be more evenly impressed upon the skin, and hence there would be very much greater strength. If this be correct, the vessels that are now being built of wood alone, with iron outside, will be under a great disadvantage; for when the iron plate is broken up it will be readily driven through the wood, which will offer no resistance or comparatively none; for when the shot has barely got through the iron plate, it will have still sufficient velocity to go through the wood behind it.

Another and important use which the skin has is, when the wooden backing is split and knocked about, it keeps the vessel water-tight. Without this, a plated-ship cannot continue water-tight under the blows of heavy shot. My own particular plan is to put a cushion outside the iron plates (plate ix), for unless the blow be deadened by receiving the first shock of the shot upon a soft substance covering the armour, the plates are injured by the concussion and vibration set up; for supposing a plate to be stretched over wood, and held by bolts tightly against it, and a shot to strike it near one end, it would indent the part hit; the wood readily yielding, especially if there be no skin to support it; and then perhaps, the plate would break, not at the point struck, but on the opposite side. That has occurred repeatedly at Portsmouth. There is another point which I think was at first overlooked, but which is, I think, now clear to a great many besides myself. We have all heard what damage was being done to the plates by bending, whether they were bent hot or cold, and the deterioration effected by the blows of shot is analagous: supposing the plate to consist of a number of thin layers rolled together, directly the shot strikes in front, it draws the surface of the plate, and the whole of the particles towards the point of impact producing a similar effect upon the layers, to that which is produced by bending the plates, and equally straining them out of their normal condition, and as the shots continue to strike, more and more deterioration and disturbance of the layers takes place. It has been observed that the round ball damage plates very much more than the elongated shot, especially than those which are flat fronted, which cut their way through without, as it were, pulling asunder the layers of the plate; but with round shot as regularly as the plate is hit hard, it buckles inwards, and the whole front of the plate is drawn towards the centre by the force of the blow.

Having endeavoured to explain how the different layers of which the plates are composed, are disturbed, and sometimes pulled asunder, I may mention that, although the hammered plates bend well, it has lately been observed, that when either are bent, the hammered generally yield to the blows of shot more readily than the rolled ones. This seems to be the case at Portsmouth, but is not so discover-

able at Shoeburyness. At Portsmouth the plates are fastened to different parts of the vessel, and if perchance they happen to be spread along, just were the beams abut on the ship's side, they are better supported than if placed in the space between the decks. In one case the backing is comparatively rigid, and in the other, the backing readily yields, whether more or less rigid. But as a rule the hammered plates deteriorate more rapidly than the rolled, when placed upon a wooden side or backing. Latterly the hammered plates have been annealed, and of course heated for the operation, but directly heat is applied, the particles of iron which, as you are aware are granular, are set in motion, and the more heat you apply, the greater will be their tendency to return to their original granular condition. The hammered plate when annealed, stands the first shot, and perhaps shows great toughness, but it very readily deteriorates under the blows of the shot, which the rolled plate does not usually do in so great a degree; but when the hammered plates have not been annealed, and have been really good, they have exhibited extraordinary signs of endurance under heavy pounding at short distances. I have pointed out that, with the usual wide plate, the concussion injures it across its width, and that when struck on one side it flies out on the other, the bolt being started, the plate itself perhaps broken. But in Captain Arbuckle's wedge bar we have a very different condition, there is a very small amount of outer surface to draw in together. The disturbance of particles would be nothing, and the vibration confined to a narrower surface when struck; for instead of great width for vibration, you have a large mass with great thickness. But supposing you do damage one of these wedge bars very much, you have only injured a comparatively small portion of the iron structure, and should the blow be on the ship's water-line, you would not damage or materially shake the whole surface along that water-line.

I will not go into the question whether they can be fastened to a ship, because that is a shipwright's question, but we are assured by Captain Arbuckle that they can be so fastened. It is a very great advantage to have the iron bars wedge-shaped, for when the shot strikes the wedge it yields a little, and if force is absorbed in giving motion, it cannot be also employed in destroying the plate. It would produce an effect somewhat similar to that which is produced upon shot moving at a high velocity, by putting a soft material in front, viz. it absorbs a great portion of the blow. Captain Arbuckle does this in a different way, and I must say, it seems to me to be the best plan that has yet been brought forward.

A MEMBER: Has that been tried against heavy shot?

Commander SCOTT: It has not been tried, but the resisting power of the bar, which Captain Arbuckle says is truly surprising, has been tried, and these bars stood, far more in proportion than the 4½-inch plates. I am speaking of the Thorneycroft bars. When they bound them tightly together, they could not break them, but from not being wedge-shaped, on the fastenings giving way, they opened a little, and then got broken in detail. They were not as thick as the wedges proposed by Captain Arbuckle. The first bar-target was not broken at all on the the early trials, but afterwards a target was made with much thinner bars, and more powerful guns having been made and mounted at Shoeburyness, the target, already too thin to withstand the former guns, was of course destroyed.

Admiral Sir GEORGE SARTORIUS: A great deal has been said about the different kinds of plating, and the mode of fixing the plating. It appears to me that the great advantage claimed for armour-plating is to make a ship invulnerable; but if heavy artillery, that penetrates plating of any practicable thickness can be made use of at sea, then armour-plating becomes useless, and all the trouble we are now taking with respect to ascertaining the different qualities of plate, making the plate and fixing the plate, becomes unnecessary. We know that so long as an armour-plate made a ship invulnerable, it possessed great advantages which counterbalanced its disadvantages; but the moment it loses the quality of invulnerability, then it loses that advantage, and becomes useless. To make my argument more intelligible to landsmen, I will take the case of a timber vessel that goes out to Canada to load with timber. She is then light, buoyant, a first-rate sea-vessel. She takes in a mass of timber, and then she becomes a heavy inert mass, the sea breaks over her, and in many cases the crew are obliged to quit her. In the same way, armour-plated vessels which under certain circumstances and in certain places would be of

great use, so long as the armour continued to be invulnerable, never could be made good sea-going vessels; they have not the qualities which make a useful man-of-war, having to cruise about in all parts of the world. Now artillery has been made which penetrates the armour-plate, and heavier artillery will still yet be made, and the enormous advantage of heavy artillery over artillery of less calibre, as Captain Scott has just pointed out, is another reason against the utility of armour-plating. If you can make spherical shot above three or four hundred pounds in weight, what plate will stand the blow? The result will be, that you must use the heaviest artillery that ships can be made to carry, and take your chance of being hit by the enemy. In my opinion, if you can make a vessel strong of wood alone, with three or four of these guns in the bow or in the stern, and having sufficient power to run a vessel down, she will be infinitely cheaper and far more powerful than any ship of the "Warrior" class. Have a "Merrimac," for instance, strong enough to carry three or four hundred pounders, made entirely of wood and strong enough to sink a vessel with a blow; such a ship would be able to carry a much larger quantity of coal, and be able to keep the sea, and should a fleet of hostile "Monitors" or "Warriors" be cruising about, this vessel having a superiority of speed would be able to choose her moment of attack, at night or in a gale of wind when her antagonists would be like half-tide rocks, not able to use their guns, and she could run in and sink them. The most important object now for us to pursue, is to continue our experiments with the guns, and ascertain what is the greatest calibre we can safely use, and then place them in ships. In the pamphlet I published a few months ago, I mentioned that I thought it possible that the heaviest guns that could be made use of on shore, could also be made use of at sea, by making the ships, the gun-carriages, and I think the plan of twin screws proposed by Captain Symonds will enable that to be done. The ship itself would form the gun-carriage, and by the aid of the two screws, guns could be pointed, the horizontal training given, and at the same time the vessel should be made available as a ram. The screws would be perfectly manageable, and the guns could be pointed with the greatest ease. Where the ram could not reach, the guns would reach. She would form about the most powerful description of vessel that could be made use of. She would be without iron-plating, because iron-plating, as I have said, is useless against guns carrying three or four hundred pound shot. All that would be required would be to apply some chemical means to render the vessel uninflammable against molten iron, which would be the form of projectile that unprotected vessels would have to dread.

The discussion was adjourned to the following evening.

Adjourned Discussion.

Tuesday Evening, March 3, 1863.

Captain E. G. FISHBOURNE, R.N., C.B., in the Chair.

The CHAIRMAN: The first subject for discussion is Mr. Sharpe's paper on the errors of the bow-gun, and the incidental subjects which it introduces. It struck me as a most interesting and valuable paper. He followed up his argument exceedingly well and illustrated it in a very clear way, so that people little conversant with the subject would be convinced of the correctness of his arguments. It is a question most important for naval men. Our artillery for the navy has been designed by persons little conversant with what is required for naval guns, and more than that, the experiments in respect to the guns that have been made, were made under very special circumstances, that neither resemble the normal condition of ship's guns nor the normal condition of guns on shore. Thus, for instance, as Mr. Sharpe very justly observed, the moment you have any inclination of the ship, you are quite at a loss with the ordinary sights. The ordinary sight would give no clue to the heel of the ship; they proceed upon a wrong and incorrect assumption. Again, when there is an inclination of the ship, and the gun trained at a small angle, in proportion as that angle is increased, which must be for each gun as more removed from the centre, the moment you desire to concentrate your fire although professedly all the guns are at the same elevation, in consequence of the inclination of the ship the guns will all have different degrees of elevation therefore with the present sights it is impossible to arrive at concentration of fire. Mr. Sharpe then went on to show the point I was alluding to, the fallacy of pronouncing guns to be fit for general purposes of war whether at sea or on shore, after trying them under the very exceptional and studied circumstances under which they are tried at Shoeburyness with a perfectly level plane, everything adjusted, and distances accurately known and everything done with a care and nicety not possible on shore in the ordinary field operations, and still less possible on board ship. For instance, when the gun is inclined, that is, when the plane from which it is fired is not horizontal, firing with elevation and the present sight it is impossible to be accurate, the shot will fall either to the right or to the left, looking at the object you suppose that you are pointing at, whereas, in reality, you are pointing to the right or left according as a gun is inclined the one way or the other from the perpendicular. With respect to rifled guns, all this is aggravated, for in every rifle, owing to the rifling, if the ball rotates one way it has a definite divergence to the right; if it rotates the other it has a definite divergence to the left, and where these distances are known and the platform level, as at Shoeburyness, the sights can be adjusted and very accurate results obtained, but when the distances are not known the attempt at accuracy is actually a positive guarantee that the object will not be hit. In the comparison between the smooth-bore and the rifled gun, the latter is at a very great disadvantage, for the adjustment of sights is for known distances; yet in all cases, whether it be at sea or in the field, the distances are not known. Mr. Sharpe has made this very clear to us, and we are very much indebted to him. He has shown the necessity of much more accurate experiments, and that they should be made under the normal conditions under which guns are used. It shows again the advantage of high velocities. Arising from the weight of the shot and various other circumstances, they have only low velocities in the rifled guns; we know very well, too, that if the rifle missile is cut shorter, in proportion as it is shortened, of course, range is lost, which was one of the great reasons for adopting

the rifled guns. There is also a loss of a certain degree of accuracy; the longer the shot within certain limits the greater accuracy, therefore to cut it short is a bad scheme for obtaining some of the advantages obtained from the smooth-bore. I think it is a very important question that Mr. Sharpe has brought before us, and one that suggests some experiments with respect to the adoption of his sight. It strikes me that it is very simple. I think it is easy of adaptation; it is a sight, as he shows us, that will hang in a pendulous way, so that when the gun is inclined, it will bring the sight itself into its perpendicular position and prevent the error pointed out as occurring with the ordinary sight. Perhaps Mr. Sharpe will answer any question that any gentleman has to put to him upon that subject.

Captain INGRAM, R.N.: I understand that if your tangent-scale be always perpendicular, then the dispart will not be perpendicular?

Mr. SHARPE: Yes, the *point* of it will.

Captain INGRAM: Because it strikes me that if the dispart inclines with the ship, and your tangent-scale remains perpendicular, you will not be pointing along the bore of the gun.

Mr. SHARPE: This (pointing to diagram) will show what Captain Ingram means. There is the top of the dispart; here is a line parallel with the centre of the bore, *the sight takes its rise from that line.*

Captain INGRAM: Of course it does, but if the tangent-scale remains perpendicular, the dispart does not.

Mr. SHARPE: It does not signify, we only want *the point of the dispart.* It is sufficient as long as that remains attached to the line.

Captain INGRAM: I mean if the tangent-scale remains perfectly upright, and the dispart inclines with the ship, you certainly cannot then be looking along the parallel centre of the bore of the gun.

Mr. SHARPE: There it is. This is where you take your start from, here is the horizontal line and your tangent-scale above it.

Captain INGRAM: That is all right, you bring that on the back of the dispart. Supposing the tangent-scale inclines with the ship, as the dispart does, how can the dispart remain upright?

Mr. SHARPE: The upper part remains right.

Captain INGRAM: If the gun is run out fore and aft, and the gun is parallel with the keel, and that gun is elevated 10°, and the ship lays over 10°, the dispart part lays over 10°.

Mr. SHARPE: The point of the dispart must be correct.

Captain INGRAM: The point of the dispart and the dispart are equally inclined.

The CHAIRMAN: It is quite a different question you are raising. The question is not the inclination of the ship, but it is the gun trained out of the right angle with the keel of the ship. It is a totally different question.

Captain INGRAM: It is the bow-gun I mean.

The CHAIRMAN: Well, the bow-gun, owing to the curve of the deck, one part of the carriage is always lower than the other, that is to say, the trucks nearer the centre of the vessel are higher than those at the side.

Captain INGRAM: I have always been taught, whatever inclination the ship has, if the bow-gun is fore and aft, and the tangent-scale is down altogether point-blank, that ship lays in any way you please, there is no error in the bow-gun.

Mr. SHARPE: There is no error where the tangent-scale is down, and you are pointing a-head or a-stern, but the moment you raise your tangent-scale, when the ship is inclining, the error commences, and in this way (describing it by a model).

Captain INGRAM: I only meant this; if the tangent-scale remains perpendicular, which it will do, according to Mr. Sharpe's plan, and the dispart does not remain perpendicular, allowing the gun is parallel with the keel of the ship, and has got 10° elevation, that dispart having the inclination and the tangent-scale remaining upright, you will not be then looking along the centre of the bore of the gun.

The CHAIRMAN: You have not examined the sight. The sight you will see you may use as a pendulum or not. You do not use it as a pendulum, unless you want elevation.

Captain INGRAM: The other day it struck me as an excellent plan, but I could not

understand the dispart being perpendicular, and the tangent-scale being out of the perpendicular.

Mr. SHARPE: You are quite right as to the dispart inclining, but we start from the point of the dispart; that part comes in contact with the straight line which is parallel with the bore. I believe I am thoroughly correct about this, whether it may be improved hereafter is another affair. The theory is perfectly correct. I shall be most happy to afford any further explanation if I have not made myself clear enough to the meeting. I fear I was not so intelligible as I could wish to have been, but there are several very neat points about this inclination, there is no error (as Captain Ingram observed) in firing directly a-head or a-stern when there is no elevation, but the moment we give elevation to our gun, the error commences, and my object in making this model is to show that the shot will commence and be discharged in a perfectly correct direction, and will then describe the quadrant of a circle when it will be discharged, not perpendicularly, but in an apparently perpendicular position—though it appears upright, it is in reality 10 degrees from the vertical line; at first sight it would hardly appear possible, that by merely giving elevation the shot would go completely round the quadrant of a circle. This, I think, I have made sufficiently clear.

The CHAIRMAN: I think so.

Mr. SHARPE: It is a very serious thing.

Commander SCOTT: Perhaps as many gentlemen have not seen the model, Mr. Sharpe will kindly show it again; one is aware that there is an error, but not of the magnitude of the error.

Mr. SHARPE: The error is really a most serious one. You will observe these models are made as nearly exact as the carpenter could make them. The angle is the same in both, one is made a little longer than the other, because it has to extend along the hypothenuse of a right-angled triangle. Suppose this to be a beam-gun firing right a-beam, and the other concentrated on it, these guns will not now be fired in a parallel direction. The ship is heeling over either to the starboard or the port tack, and we are concentrating or converging our fire, whichever you like. The guns have had a certain amount of elevation given them to compensate for the heel of the ship. And the error I wish to show is this, that with the present pendulums we can only give the direct heel of the ship, which is only applicable to a broadside-gun, directed at right angles with the heel, for the moment you begin to train your gun to the right or left of that position, that moment the error commences, as you may observe (referring to the models). That is about half the error. We started by saying that an elevation of 10 degrees was given to bring the bore of the gun horizontal. We will now go on training our gun until it is pointed directly aft, when the gun will actually have an elevation of 10 degrees.

The CHAIRMAN: Pointing at an enemy coming up or approaching either from the bow or stern, you would fire over him.

Mr. SHARPE: Exactly so; ten degrees is a very serious error; you must be aware what an amount of range that will give you.

The CHAIRMAN: I said that velocity was important, that the high velocity of the shot was important, and that it was involved in this question of the sights, which were made necessary for the use of the rifled gun. I will just take an illustration. The Horsfall gun is said to have a point-blank range of 600 yards; it is approximately that; the Armstrong 110-pounder gun may be said to have a point-blank range of 300 yards, it may be a little more or less, I assume it is that for argument. The consequence is, that you must give an elevation to the Armstrong gun, or to any rifled gun in order to get 600 yards out of it. Well, you see at once, the moment you get elevation you get error with the bow-gun, and the moment you get elevation you also get the evil of the present additional adjusting sight. Then we know that the force of a shot striking, is as the square of the velocity, therefore, as an offensive weapon, to say nothing of a defensive weapon, though I believe the very best method of defence is to give effect to offensive operations against an enemy; I do not see there is a single redeeming point upon which anybody could venture to justify a low velocity, and yet both in this theatre, and practically, it has been asserted that it is a matter of indifference whether we get high velocity or low velocity, though the former for the greatest effect is indispensable; and I think we ought to be very much obliged to

Mr. Sharpe for working out a question of this sort so thoroughly, step by step, and then illustrating it in so clear a way as to make it, as I said the other day, extremely easy—a difficult subject made so that anybody can understand it.

If any gentleman has any remarks to make on Captain Arbuckle's paper on the subject of plating, which was read last night, we shall be happy to hear him.

Commander SCOTT: If you will allow me, I wish to make a remark upon that paper. I do not observe that particular reference has been made to one point which I look upon as of great importance. Captain Arbuckle put up that ship of mine to refer to; I beg to say it was his wish it should be there. (Plate viii, fig. 2.) I particularly designed that vessel for firing a-beam, and I am very glad to hear Mr. Sharpe so clearly elucidate the errors that you at once fell into directly your guns are not pointed abeam. In fact, if we worked heavy guns, it would be found necessary to fight them very nearly a-beam, you will get greater accuracy, you will have a much more certain aim, and you will have at the present time with the double screw, an opportunity of keeping your vessel steady, and firing your shot right a-beam. There is another special point in relation to that subject of firing a-beam, which is the necessity for the rudder, which would be so liable to be hit, being under water. In not a single vessel of ours, up to the present day, is the rudder under water, so that it is exposed to be knocked away, and your vessel left a helpless hulk on the water. None of our large vessels, such as the "Warrior," which we all know will not turn with the facility required, have any means, if their screw is injured, or their rudder is injured, of turning. So that at once, with a single shot of a 32-pounder hitting the stern-post, your "Warrior" is gone as a vessel of offence, she must lay as a log upon the water, perfectly helpless. I have seen a statement to-day in the *Times*, and it is necessary I should refer to it, because it somewhat bears upon the present question, (and it seems to me, that taking up these things in the remarks of the press, from time to time, and the leading journal which is said to have so much influence upon public opinion, that it is necessary, as we are discussing an analogous question,) that we should turn to that statement, and examine its correctness. In that article of to-day, speaking of the "Montauk," which carries two of those very large guns of which we have heard, the 20-ton guns firing a 430lb. shot, the *Times* states it did no damage to the fort, on account of its very low velocity. The fact is, we do not know the whole of the conditions, therefore we really do not know the amount of damage, but we do know that these forts have been covered first with iron-plates, and then with railway bars outside, so that there is a double coating of iron-plates, and we have no means of ascertaining the amount of damage done to them. The real fact about those guns is, that in the cupolas in which they are fired, they are unable to use very large charges on account of the sharp and heavy recoil of the gun. If they were working those guns in forts they could use high charges; out of the later guns that have been cast in America, they have been getting a velocity of 1,400 feet a second. What is the force of the blow due to that velocity of 1,400 feet? Then you will be able to estimate what is the effect that such a shot would have upon the side of a vessel. I speak of it because the comparison has been made, and it is forced upon us now from observing the effects that some rifled guns have in comparison with smooth-bores, to examine if smooth-bore guns are so defective as they are supposed to be. I have a table here (Table II, page 44), and I think I can point out to you some points that will be instructive. The striking velocity of the Whitworth shot that went through the 5-inch plate, through the teak backing, and also through the skin, was only 1,220 feet a second. That shot weighed 120lbs. The initial velocity of the gun in the cupola with the highest charge that they have yet been able to safely fire at sea, is, as you will see here, 1,282, so that you have this mass of 430lbs., moving 1,282 feet a second—three times the weight, and with a higher velocity than the Whitworth. We know that force cannot be lost, and that that big shot moving with that high velocity must do much more damage than the Whitworth at a low velocity. It is quite clear none of that force is lost, that is, and must do more damage to a ship on striking her than the Whitworth actually did. But the truth is, that this United States gun is capable of a velocity of 1,400 feet a second. We have found that by mixing a little wrought iron with the cast iron of our shot, we have made them a great deal tougher, and I have little doubt they put a quantity of wrought iron in their cast iron guns, so that the new guns are considerably tougher and able

to bear large charges. Why cannot they bear those charges, or why cannot they use such charges in the cupolas? The concussion of very large charges inside the cupola is felt over the deck it is fired over. The effect of very large charges is to make such a recoil that scarcely anything will stand it unless you have space. The largest American cupola has only 20 feet clear inside, and therefore not length for the recoil produced by large charges. I do not think people are aware of the space that it takes to work guns in general, and it is a very important thing, and it is the reason why I say we must have guns on the broadside, it is the only way we can work them. It has been reported officially that it takes 17 feet 6 inches to work a 68-pounder, so that we can easily see that when you come to work a 20-ton gun with these very heavy shot, when you will have a considerably longer recoil, that there is not breadth in the cupola, and they dare not fire a sufficiently heavy charge to give a high initial velocity. I have merely made these remarks to show you that the smooth-bore gun is really a much more formidable gun than it is generally supposed to be, and that it is only because it is used under exceptional circumstances that it has not proved so formidable as it might readily be made. My object in designing these vessels is especially to carry big guns. I do not go into the question of screws; that belongs to my friend, who does it very well; I will not trespass on his province. I do not go in for the rudder under water, for Captain Symonds knows that two years ago I proposed that very thing, but I found Captain Symonds had proposed it before, but had carried out his plan in a different manner. But I have gone in for the working of guns, and the concussion upon the ship, and if the meeting would allow me I think I should like the opportunity, as I have never clearly stated it, of specially explaining these points. This vessel (Plate viii, Fig. 2), is intended to be 280 feet long, 58 feet broad—what the "Royal Oak" would be—and with a draught of only 17 feet of water. She would have, as you see, two decks; a light cable deck, which I hold is a very essential thing, and above that a living deck, which you see is perfectly free from the iron-clad part altogether. The cable-deck would be about 1½ feet above the water, her plating being about 2 feet, except at the ends, where they would be carried up 3 feet. The deck would have a little rise and be carried high in proportion. That bow is not my bow; that is put on by Captain Selwyn to show what a bow should be; and, as you observe, my plating is not there I believe myself the plating should be carried very much lower than we at present think of doing; instead of being 4 or 5 feet under water it should be carried down 7 or 8 feet, inasmuch as guns can now be fired under water. Several experiments have been tried, and a shot has been sent a considerable distance under water—20 or 30 feet, and they expect to reach 40 or 50 feet, and to go through 3, 4, or 5 inches of planking. But contrary to what you have heard stated, the shot with a round end goes better through water, as you may suppose, than a shot with a flat end. However, to turn to this vessel again, I have spoken of the effect of the impact of shot, and the effect of concussion upon plates, but I did not speak particularly upon the effect produced upon *the vessel* which I look upon as a most serious thing, and I believe at the present time, if we cannot strengthen our vessels, our "Warriors" and the whole of that class will be very much better without their armour-plates, for although we may use light guns, and although we may punch small holes, and do other things of the kind which do not disturb the plates, yet they will not be able to stand shot from the heavy guns which are now being made. The Americans are going in for large guns, and you will find the only thing they want is high velocity. They understand what high velocity is, just as well as we do, and their agent who was over here not long since, came to me to know what metal could possibly be obtained, so that they might get the very highest initial velocity out of their guns. I am therefore positive that they are perfectly well aware of the value of high velocities and heavy shot. Supposing they carry out their object, the effect of a large shell striking, would be to go right through, breaking in the side. As I have said before, one part that has been neglected, is the part under water. The lower part of the target has always been very much damaged, and displaced, but yet it seems to me to have received very little attention. At Shoeburyness I observed the target had been driven back altogether, showing what an enormous amount of force there must have been to drive this mass backwards. That has not been taken into account, and it is a most

serious thing, because the effect upon the ship would be very great. The purely iron vessels are built, as we are well aware, with rivets. When a jar comes upon these rivets what will be the result? Iron is positively a better conductor of vibration than it is of heat; it is a perfect conductor of vibration, and when a thin plate is put in front of an iron backing, as long as it is put closely against it, you will find you produce very little impression upon it, because the iron behind so readily conducts away the force of the blow. Wood on the contrary is an absorbent; if wood were a good conductor behind a plate, you would get two things, you would get the jar conducted away, and you would get it absorbed, but as you cannot get that, you would have to take off the force of the blow first.

As respects the bottom of the vessel, and the effect of shot upon it, what I have especially proposed to do is—I have merely indicated what should be done, nothing more—I leave others to work it out. In the front of the vessel I put, instead of the backing, whether it be wood or a much tougher material, such as paste-board, I put it on the outside, and then my iron-plate underneath, the iron-plate being brought right against the ribs. Now, you would have in that case the rigid backing, which has been found to offer the very greatest resistance, and you would have the soft material in front acting as a cushion and reducing the velocity of the shot to a velocity that will produce no effect upon the iron, because a low velocity produces very little effect; that was shown at Shoeburyness. When the 150-pound shot was fired out of the Armstrong gun, it scarcely indented the plate at all, while the 68-pounder smooth-bore was making 2¼ inches and the 100-pounder 1½ inches indention. When they fired the shot so much heavier, it merely made an indent showing that without velocity you produce very little effect indeed upon plates. To go a step further, unless you have the rigidity of the iron frame, in your vessesl rolling and tumbling about, you will find that they will certainly never stand that weight of armour without leaking, and especially when hit, they will very rapidly leak, and your vessels will go down in action, or after an action. What you want then is, after you have broken the force of the blow to absorb it. If you have got your rigid structure to withstand the blow, then there remains to absorb it, and I believe that can be done by putting between your iron frames wooden timbers, exactly as you would build a wooden ship. I do not go into the shipwright's question, but in a general way I should propose to place these iron ribs just as you do in building an iron ship, so that the vessel would be a perfect hoop, perfectly strong. Then between all these iron frames, put your usual timbers, then outside that bring your wood planking, carried up, as I said before, right over and covering everything. So that you would have outside a perfect wooden ship; you would be able to copper her. She would keep the sea at all weathers, instead of as proposed for iron vessels, having docks in all parts of the world. Sailors know what a dock is; just at the time you want the vessel, she is in dock: your iron vessels will be never ready, from their rapidly fouling; if the vessel grounds, &c., we know that the iron-skins tear. I believe some such plan as I have mentioned will give us a powerful vessel, and some such plan of working the guns, as I have proposed here, will enable you to carry very heavy guns. You see, the guns are not opposite one another. Although the deck is 58 feet across, I allow my guns to interlace or recoil; they are 20 feet apart, so that I have ample space to train several points, and I can, by pinching, train a great deal more if I like. Instead of 20 feet, I can give 24, 26, or 30, so that I do not produce any strain; I allow them to recoil, as I mentioned yesterday, along a slide, while, with a proper compressor on the outside, I can gradually bring up my gun, and by a system of pauls keep it steady.

Rear-Admiral Sir EDWARD BELCHER, C.B.: Not having heard the paper read, I hardly know to what to confine myself, but there are one or two observations that have been made, that I should like to throw some light upon. In the first place the steering below the keel is not new. It was tried by Shuldham in 1815, I was an actor at the time racing against him. He used a rudder somewhat of the shape of an harpoon, below the keel, and he turned his vessel at Spithead and Plymouth, and other places, with greater rapidity than any other vessel could be turned. I am not taking away at all from the credit of my friend, Captain Symonds; I am rather advocating his rudder well below the water, because I am perfectly satisfied, from what I saw of the harpoon-shaped rudder in that day, that his rudder,

having a greater surface, being better placed, and the water being led to it between the keels, will have infinitely more effect than a simple harpoon sticking through a round bottom.

I now come to the shape of Captain Scott's vessel. Experience is much better than theory. If that vessel be so laden with iron, that that iron oppresses her, and the fore-part of that vessel be built to sustain the shock as a ram, she will just be in the opposite condition to our rams we used against the ice, which lifted their noses above the ice, lifted the whole bow of the vessel up, then re-launched and went astern. Now I maintain, that if that vessel with its bow adapted precisely to the sectional curve of bottom of the "Warrior," attempted to run against the "Warrior," she would go down nose foremost; from the quantity of iron she would carry. From the leanness of her bow, and the facility of immersing that bow, she would run her nose dead under the "Warrior."

With respect to the question of gunnery, I have seen a great deal of that in my time, and I am delighted to see science acted upon to its very nicest point, but in former days I have seen an old seaman take aim at a bottle hung from the fore-yard of a 74-gun ship. The first man was a marine officer, he knocked away the bottle, neck and all. The captain of the forecastle thought he was a better shot, and also thought it was not fair play that nothing remained to prove what the marine officer had done. He took his aim, knocked away the bottle itself, and left the neck hanging, proving that he was the better marksman of the two. Educated, as our officers are, to the nicest point of gunnery, they will have all that talent added to that greater talent, a good eye. We find, at least I know, that firing a rocket from my hip, I could hit a tree at 1,500 yards, and set fire to it. I know that firing a fowling-piece from my hip I could knock over a snipe, and so our experienced seamen, who are also highly educated gunners, will, by their eye, take very good aim, and will, I think, unerringly hit their mark.

Commander SYMONDS, R.N.: I should like to make one or two remarks which I think may probably be interesting to the meeting. Mention was made last night of the power of pointing guns by means of the twin screws. Now, it has been done in America, the "Nangatuck," an American gun-boat, was fitted with one very large Parrott gun, I forget the diameter of the bore, but one of the largest guns they employed; this gun was fixed on her deck; the recoil was taken up by india-rubber cushions before and abaft the trunnions; the gun was literally pointed by the screws, and very good line firing was made. There were several remarks made on the point last night, and I think one instance to prove that the thing has actually been done, is perhaps valuable; of course the gun was elevated and depressed in the ordinary manner, but literally the gun was pointed by the screws, and the firing was excellent; this I have heard from witnesses. With reference to some observations which the lecturer made on plates, I would observe, (following up his remarks, which tended to show that all bent plates were very inferior, whether bent cold or hot) the plans which I had the honour of bringing before this Society before, show, that the method of construction I propose, gives you three-fourths of the side, vertical and parallel, by which means you may actually put three-fourths of the armour-plates on without the slightest bend, and the curves of the bow and stern have no, what I may term varying curves, and that, therefore, in the most delicate part of the ship, there will be very slight bending indeed. Now, although vertical sides are not generally admired, I think that perhaps if they were more strictly observed in building armour-case ships, that it would be a decided advantage, that it would be certainly a cheaper process of putting on armour-plates, and I think, as practice has shown, it would be a far more efficient one, inasmuch as the plates would not be weakened by the process of bending. There is only one more observation I would make, which is this, that I think that sufficient stress has never been laid on the funnels being entirely protected. I have read, and I have heard from those who have been present in the actions in America, that the very first attempt made has been to destroy what they call the chimney-stacks, and in several instances, of which I have no doubt most of you have read, the chimney-stacks have been shot away, and the vessels disabled. In a cupola ship, we will say for example, the chimney-stacks are not defended, whereas in any fixed shield-ship, you will observe there is sufficient length of funnel defended by the armour-plates, to

enable you with the aid of artificial means of draught, actually to keep up your fires during the action, without the slightest fear of injury to your funnels, and if those funnels are made on the telescopic principle, which I have no doubt they would be, under ordinary occasions, you will have the usual draught due to the height of the funnels. I think I am not wrong in stating, that it is a very material point to protect your funnels. And, moreover, in the vessel you see before you, the masts are intended to be iron, which is a very common application now, but there is a use beyond that which has generally been given to them, which I propose to adopt, namely, to get a draught down to the boilers from the mast-heads. I can safely speak from the experience of those who have been in action in steam-ships, that before the action has been half over, the fires have been very nearly put out. This point was confirmed by a gentleman, the other day, on board the "Kate." He had to report that the exploded gunpowder had been borne down to the engine-room by the draught, and that literally the fires had been nearly put out. Several officers have informed me of the same fact; therefore I mention it now. I propose so to seal up the boiler-room in action, that no exploded gunpowder, no smoke, can come down to the fires, and to obtain a draught from the mast-head by means of a fan, which, I believe, has been adopted in one or two instances, to ventilate the ship, and by that means we shall obtain a clear draught to the fires. I shall not detain you any more on the subject of my adaptations; I think I have already said quite sufficient.

Mr. BARRASS: I should like to confirm this gentleman's observations with reference to the vertical plate, for it is one that ought to be very generally understood. Being an engineer, I can speak with some confidence on the subject. The resistance to projectiles of armour-plates placed vertically, relatively with those placed at an angle is greater than might be imagined. If a shot strikes a vertical plate, it must separate the whole of the fibres at once, if the shot has sufficient momentum concentrated in itself to overcome that resistance, and sufficient cohesion in its particles to conserve its *vis viva* in penetrating and not in breaking itself up, while if you place that plate at any incline you like, let it be at an angle to the horizon, or at an angle to the vertical line of fire, the shot on striking only meets the resistance of the portion with which it comes in contact, and which, being a small portion, offers but little resistance to the onward progress of the shot, and by the time it has gone a little further, the plate will have commenced to fracture, before a considerable portion of the fibres which must ultimately be separated, have been disturbed, but still the momentum of the shot not being arrested, it passes through gradually as it were, separating a portion first, and then another, until it ultimately passes right away through. You can put it into the form of a simple equation. Let P represent the power, or the force actuating the shot or the punch, whatever you like to call it, D, the diameter of the shot, T, the thickness of the plate to be penetrated, then D. 3·1416. T, will give you the whole area to be forced out by the shot, and if we now multiply these quantities into the co-efficient of the resistance of the iron, which, we may say, is 20 tons per square inch, we have got, expressed in tons, the effective resistance of the plate, and if the force of the shot is just sufficient to effect the penetration, and nothing more, then we have P = D. 3·1416. T. 20. Let now two plates 4 inches thick each be taken, one placed vertically, the other placed at an angle to the line of fire of 45°, and let the shot be 8 inches in diameter, and its velocity uniform during the time of penetrating each plate, then the relative times it takes to effect the work of penetration in the two cases are as 4 to 8 + (4·$\sqrt{1}$ + 1), or 4 to 13·656 = 1 to 3.414, that is to say, the time required to penetrate a plate placed at an angle of 45°, 4 inches thick, and with an 8-inch shot, is nearly 3½ times that of a plate of the same proportion placed upright; but the area to be penetrated being increased, as well as the time of penetration as the secant of the angle of the plate, we have, for the ultimate reduction of strain upon the shot $\frac{3{\cdot}414}{\sqrt{1}+1} = {\cdot}414$; that is to say, the strain upon the shot during the time of penetration is 59 per cent. less in the angularly than in the vertically placed plate. This reduced strain is not uniform, but it is the most favourable for permitting complete penetration, being a minimum at the commencement and at the conclusion of the penetration, and the amount of

the reduction of strain per unit of time, supposing the resistances in both cases to be uniform during their times of penetration, being in the inverse ratio of the duration of the time of penetration, and directly as the ratio of the area to be penetrated, leaving a superiority of resisting power to the upright plate of 1 to ·414 or 59 per cent. Therefore, instead of getting a greater resistance, as is sometimes supposed, or placing the material in a form which might be supposed to induce the shot to ricochet and fly off, according to the usual law of making an angle of reflection equal to the angle of incidence, you really have a much less resistance to the force of a projectile. I think that is a point which ought to be very clearly understood. I might state that engineers and shipbuilders are now taking advantage of it, and are punching large holes 12 and 15 inches diameter, with the ordinary machines, by placing the punch or the plate at an angle, and reducing the strain upon the machine accordingly, giving the punching-machine a longer traverse in doing the work, for since the work to be done is very nearly the same when the plate is a thin one, by increasing the time of doing it, the resistance is reduced and the strain upon the machine in the inverse ratio of the time required to punch the hole, and large holes which used to be made by making a series of small ones, and trimming them out afterwards—a long process, and leaving very rough work—are now effected at one operation and leaving good work, as may be seen at the Thames Iron Company's Works. Now the same principle applies to all these angular-plated systems, Captain Coles' cupolas, my friend Mr. T. Roberts' serrated outlines, and many other ingenious measures, for while they are prepared to throw off the shot, if the shot have a high velocity, and therefore a large quantity of power stored up in it, it will not be deflected from its line or direction of force, but will cut its way through.

The CHAIRMAN: How would the argument be effected by a great difference in the initial velocity?

Mr. BARRASS: The greater the velocity the better, and the smaller the diameter of the shot.

The CHAIRMAN: Then you think if the velocity were reduced down to a certain point——

Mr. BARRASS: The advantage would be entirely lost; with a low velocity that very action takes place, which I have before mentioned, and which I believe you designate by "ricochet," or an action is obtained similar to that produced by "ricochet fire," penetration does not take place; the shot is deflected from its line of trajectory It all depends upon the velocity. A shot travelling at a high velocity, and, therefore, having a great force in its line of flight will not be deflected from that line of force, on striking the surface of an object if that force in a given line, be sufficient to overcome or displace the material opposed to its progress, whatever may be the angle of the surface of that object, deflection from that line of force will only take place when the velocity of the projectile gives out a momentum or force, less than the resistance of the plate, whatever may be the angle at which it is placed. Next to the great importance of a high velocity for effecting penetration, is that of a small bore, and having elongated shot, as Hutton showed many years ago, that by making elongated shot and storing the means of momentum in the smallest area, and therefore meeting the smallest area of resistance in the object you fire at, the penetration is more easily effected. In the present instance, however, the shot must not be materially less in diameter, than the thickness of the plate, or absolute penetration does not take place. There is also another point bearing on the question of the penetration of armour which might be mentioned, namely: the form of shot for operating on armour-plates, that partake of a curvilinear slanting, or irregular shape. Now, though Hutton's tract, No. 34, as I have just mentioned, lays it down that you get a little advantage in momentum, by making shot elongated, and lessen the atmospheric resistance, Mr. Sharpe, an engineer, on a paper being read here, and at the discussion which took place upon the subject, remarked that you lose nothing in power by the mere form of the shot, and, therefore, that it may be either spherical or elongated, whatever may be the work to be done. This appears to me to be quite correct, and what you lose in velocity with the elongated shot, you gain in weight, the other element constituting momentum, and what you lose in weight with the spherical shot, you gain in velocity, according to the second law of force or motion, if you have burnt your

powder thoroughly you get the whole force of the exploded powder upon the shot; which force will be delivered upon the object by the shot, irrespective of its form. Be this as it may, however, if you have an enemy with these angular sides, it appears to me that all you have got to do is to have short pieces of cylinder as well as round shot to do your work,—if you have angular sides to deal with, have a cylinder and smooth-bore, of course. As you have established, Sir, in the lectures you have given here, the rifled guns must necessarily absorb some of the work of the powder, indeed they absorb the work of the powder to the extent of the rotating motion which you give the shot. That work you don't want done in broadsides; what you do want is the maximum of the work done by the powder to be expended in sending the shot straight to its work.

The CHAIRMAN: Did you hear Captain Arbuckle's lecture?

Mr. BARRASS: Yes.

The CHAIRMAN: You saw his plan?

Mr. BARRASS: Yes.

The CHAIRMAN: Have you any remarks to make upon the peculiar style of his plan?

Mr. BARRASS: Well, it struck me as being rather ingenious, but it is not an efficient plan, it looks strong here in the wood model with the segments glued together, but in actual construction, the iron segments would not be, and could not be, attached to each other, in a manner that would be a fair representative of the glue of the model; it also looks strong because it is in the form of an arch, and, I understand, has a tie-rod behind; and thus, though appearing strong and simple, is put together in such a manner, that if one piece or segment was damaged or displaced after an action, you would almost have to take it entirely to pieces and rebuild it, to repair one piece. This, I think, is rather a serious objection, and after being in use for a few years, the joints, and there are a great many of them, being open to the weather, the corrosion would be active and destructive, and to get out one segment, you would be obliged to pull it all to pieces. In the plans which I have laid before the Iron Plate Committee—and therefore I suppose I must not say much about them here—there are no joints open to the weather, and any one plate can be taken off after an action, and be repaired or renewed without disturbing its neighbours. There is one more objection to Captain Arbuckle's plan, and it is one common to a great many of the plans which are brought forward for the application of iron to forts; namely, that of employing a costly material, and, as it were, building it up like a piece of brick and mortar work or carpentry, instead of developing upon it a mechanical skill and detail of construction in iron, calculated to ensure a durability and efficiency, commensurate with the costliness of the material employed.

Captain TYLER: I wish to make one or two observations upon the subject of Captain Arbuckle's plan. With reference to the general history of armour-plating, there is this observation in common with the history of other inventions, that the inventors very often fail to seize the first principle involved. I believe the first great discovery with regard to armour-plating was, that one large thick plate would offer a very much greater resistance to shot and shell than a number of thin plates combined. Now many of the inventors of systems for fixing armour-platings have broken up these large thick plates into smaller ones, in order to fasten them on to their vessels, and of course the targets made have been the more easily penetrated. Mr. Hawkshaw's target is a remarkable instance of that point. Captain Arbuckle, I think, seized that idea plainly enough, but he has somewhat a tendency to fall into a similar error, in using these wedges, he sacrifices width and size in one direction to excessive length. I think that he no doubt believes that the effect of a shot upon his target or upon his fort, would be to drive the different wedges together with a stronger compression, and in that way to make the fort stronger. I believe myself that that would not be the effect. The effect of a shot striking any particular wedge would appear to me to be to drive that wedge into the fort, or to tend to do so, and rather to drive the others outwards. The effect of the shot also striking the end of the wedge would be to break off that end, or striking the middle to tend to fracture it in the middle, and to throw out the two ends. It seems to me that a fort that had been fired at frequently, a fort as described by Captain Arbuckle, would be thrown into

a very irregular condition; some of these wedges would be driven in, others would be forced out, and the fort wanting transverse connection, would be inclined to fall to pieces without any further firing at it. So much for the construction of this fort, but Captain Arbuckle proposes to employ it in such a way that I should like to make an observation upon that point. I think I can explain my meaning in that respect very simply. In constructing modern works of fortification, a very great expense is entailed by the enormous extent which is necessary, in consequence of the great range of rifled ordnance, so that in many cases a circumference of some 20 or 30 miles is required in order to protect a town, or an arsenal, or a dockyard, or whatever requires to be protected. Now Captain Arbuckle proposes that works so constructed, a chain of fortifications round a particular object extending it may be 10 or 15 or 20 miles, shall be protected by other works placed outside of them. That, I believe, is his idea, and those works are to support one another. These works would, of course, necessarily be of a still greater circumference, would be dotted about on positions in which they could be placed, so that in a very short time we should come to 10 or 20 of these works extended on a large circumference, and if each of these works cost £50,000, for I believe each work is to be self-supporting, although they are to flank each other—they are to be within flanking range—yet each work is to be self-supporting, that is, to be safe against attacks, it is to have an escarp and counter-scarp, and counter-mines, therefore we soon run into a great expense. Twenty of these works at £50,000 cost £1,000,000, and the expense of surrounding any object with such a chain of forts which we now possess, of course, would be very much against the scheme. But there is another reason that is still more against it, and that is that these works would not be required at all, for the effect of modern weapons is to increase the properties of defence, rather than those of offence. The great difficulty in future will not be to defend places so long as the fortifications around them are suited to modern weapons, and provided with bomb-proof covers. The great difficulty will be not to defend these places, but to attack them. It will be impossible to throw up works in daylight in the face of a fire from the fortified works, or to make any attack upon them in daylight. Therefore, I think, such works protecting them from attack would be less required than ever, and still less in this country, because all we have to do now is to make such fortifications so strong, that there is no chance of their ever being attacked; when we have done that, we have done all we require, and the question with our fortifications is rather whether we have spent more money than is necessary to attain that object, rather than whether we shall expend more to do more to attain that object. I do not know whether I shall be justified in touching upon the subject of ships, but I am sure we must all have felt very strongly that there is a great deal of truth in what Sir George Sartorius said last night on the subject of building these ships plated with thick plates of iron, that hereafter when 200, 300, or 400-pounder guns come to be used with large shot at high velocities, that the thicker the plates on the sides of these vessels, the more dangerous they will be for the crew that they contain. I think it will be necessary to use some thickness of plating, though it will be difficult to determine it, and it is impossible perhaps to determine at present what that exact thickness may be. No doubt it is absolutely necessary that at present we should go on building some vessels plated with thick plates; these vessels are superior to any other vessels when they meet them; no wooden ship has a chance against an iron vessel with the guns now in common use, but as larger guns come to be used the thick plated vessels will no doubt be very unpleasant things to defend. I cannot help sympathising with my brother officers of the sister service, in thinking what they are coming to; whether they fight in wooden ships or iron ships, whether the plating be thick or thin, it appears to me that as soon as they go into action, when these enormous guns with large shot at high velocities are introduced, they will all very soon go to the bottom.

Sir GEORGE SARTORIUS: Sir Edward Belcher made an observation with regard to a vessel running down others. He objects to the ram system as has been generally adopted by almost all nations.

The CHAIRMAN: Hardly that, he objects merely to that description of bow.

Sir GEORGE SARTORIUS: I mean, that Sir Edward Belcher thinks that vessels

ought to be made to run over and not into an enemy's ship. He quotes the case in the northern expedition, of vessels running against ice. There is no comparison, I think, between the two; the one is a large inert mass of ice, and in the other vessels are contending against each other, and are pretty nearly of the same size. I think I have experience to support my view of the matter. We see collisions constantly taking place, and the ship that runs stem on into the other, bursts in her sides and sinks and destroys her, and receives no damage herself. The "Merrimac" ran into her vessel, stove in her side and sank her. In fact, it appears to me it is such a common-sense mode of proceeding, that it is hardly necessary to make use of argument to prove it. Supposing two vessels of the "Warrior" class to be running against each other, it is impossible that one could run over the other in the way that a horse would go over a gate; but a blow with sufficient force must burst in the side and do the mischief which has been done in innumerable cases, and will be done again.

With regard to the iron-plating, I will repeat an observation I made last night. We have already passed the thickness of iron which is of use for practical purposes at sea. Guns have been made which already have penetrated the thickest and most powerful defence that has been yet invented. We are going on developing artillery, and I do not know what limits artillery will arrive at. Therefore, it is quite clear if the armour is penetrated with artillery of comparatively small calibre, when the calibre is very much increased, of course no iron-plating, no "Warrior," can possibly be of any service; it loses all its invulnerability; once losing its invulnerability, it loses the only good it had. There are many disadvantages which iron vessels must necessarily possess, and the disadvantages are felt, the advantages are lost through the improvement in artillery. Even now, supposing that the artillery had not made the advances which it has done, I think if we reflect upon the subject, we must admit that a vessel expressly made of that enormous strength, for the purpose of sinking with a blow, without any kind of iron protection but with superiority of speed, will always be able to burst in an iron-plated vessel, by watching proper opportunities—for instance, at night. Suppose a vessel without any iron-plating whatever, but made of immense strength, for the purpose of sinking by concussion; she has no masts up, all her masts are lowered down, she presents her sharp bow, she is comparatively invisible; the large iron-plated vessel is seen, all its masts are up a considerable height above the water; on a dark night, a vessel of this kind running into her, would not be perceived until she was within about a minute or a minute and a-half distance of the vessel; by the time that the look-out man calls out, "The enemy is upon us!" the vessel would be upon her and burst in her sides, and particularly so in very large and *long* vessels; they are slow in paying off, they could not avoid the blow by paying off. We all know when the helm is first put over, that two or three minutes will elapse before the force of the helm is felt, which gives ample time for the ram to give her blow. If the strongest armour-plated vessel is at anchor, or in a gale of wind, when she is knocking about like a half-tide rock, with the sea bursting into the ports, she could not fire her guns, and then this unprotected ram could in the same way run in upon her and burst in her sides. All these circumstances, together with the development of artillery, and the facility, under circumstances which may always occur at sea, render, I think, any further continuation of armour-plating a very useless question in my opinion.

Sir EDWARD BELCHER: I beg to make one remark, that in the case of the "Merrimac" running into the other vessel, she ran into a wooden vessel, but when she tried a second, an iron-coated vessel, I have it from six American officers who were present, whom I conversed with the day before yesterday, that if she had not got away she would have been lost, for her nose was destroyed completely by the "Monitor," and I asked them the question, "If she had had a rising bow, and could have gone at her, what would have been the result?" they said, "The 'Monitor' would have gone down."

Sir GEORGE SARTORIUS: The "Monitor" was close down to the water's edge.

The CHAIRMAN: The argument seemed very plausible, but it was contrary to fact that the experiments had been made, and it was in consequence of a remark that Captain Tyler put to me quietly that I asked the question of Mr. Barrass about the

velocity. I believe the two cases are facts; I believe the illustration of that case of the punching-machine given by Mr. Barrass is an undoubted fact, and the argument founded upon it is perfectly logically drawn, and we must come to the same conclusion. I believe the real difference between the two facts, the reconcilable thing is, that when we have been working with these shot, we have been experimenting with low velocities, and we fancied plates would not be pierced because these guns did not pierce them. This wonderful gun did not do it, and nothing else could do it; that was really the argument. I believe if the experiments were made over again, with shot at a high velocity, and, as Mr. Barrass has remarked, with cylindrical shot or flat-headed shot, or shot which present an angular point to be inserted by degrees, and thus introducing the element of time, I have no doubt there would not only be the element of time introduced, but also the leverage for fracture. I have no doubt in the world that what Mr. Barrass said would be the case. There is also an embarrassing point about the angular plates, viz., that in proportion as the angle is great, there is a greater addition of weight of iron necessary to produce the result. That is one of the difficulties with all plated ships,—the difficulty of getting a good man-of-war that presents a tolerably stable platform for her guns to be used upon is already felt. With the incline plates you introduce an increase of the disturbing element, viz., the addition of the plates which, I believe, will put it beyond the power of anybody to give any satisfactory shape to a vessel that would be stable for her guns. There is the "Warrior," she by report, rolls 38 degrees. I have not the least doubt in my mind that there is no difficulty in designing a vessel that would not roll 20 degrees, while that vessel was rolling 38. The one may have as much armour as you please upon her, the other is only a wooden ship, but she has speed, speed obtained by dispensing with the enormous weight of iron, you can put in any engine power, and you have of necessity immense speed, you choose your time and position for attack, and have a steady platform in that class of vessel, while these vessels are unable to open their ports. I believe large guns will be got with high velocities without difficulty, I have not the least doubt of it. If only a proper method is adopted, you will get a description of gun that would admit a large shot to be fired with large charges, and, therefore, with high velocities and that will knock in any sides. Captain Scott alluded to a point, but did not bring it out, which I think is an important one. Sir George Sartorius alluded to it on a previous night in very graphic language. He spoke of the piercing plates as gimlet-holes. Just in proportion as you pierce the plate you relieve the ship from a great shock, and the frame of the ship too. I believe the object is not so much to pierce, as to break in, and damage the whole fabric, the second or third shot will do a degree of damage that will not be done by 50 of these gimlet-holes that Sir George spoke of. Therefore in regard to what Captain Scott says about the broadsides with these large guns, the disparity is even greater than he has given it in his table. I believe the damage that would be done will be somewhat in a very greatly increasing ratio to the size of the gun. I think that heavy plating is a mistake, we are over-estimating it somehow. I do not know whether it belongs to the English mind or what it is, but we take a new step and we seem to be carried right away by it, and fancy because it is new it must be true. I believe the excessive desire to have plated ships is a great mistake, and we have seen it in the case of the "Alabama." It is very desirable that we should not be hastily carried away. The value of these discussions is, that they give people who have thought over the matter, an opportunity of exchanging their ideas, and of encountering the tendency of people who say, "we do not like to run counter to the general opinion; general opinion must be right." We are very much obliged to Mr. Sharpe and Captain Arbuckle for the interesting papers they have given us.

Commander SCOTT: With reference to the objections to these plates, as Captain Arbuckle is not here, I may state that he intends to have a dove-tail fastening behind these plates, so that they will be held together. I never heard him say that every blow against the fort would make it more rigid, because that would be absurd. All he said was, that the effect would be to drive these wedges a little tighter. And then again, if you take the length, what he pointed out was, that with these large guns, (I do think that is the material point after all,) 5, 6,

or 7 inch-plate, or even 9 inch-plate would not stand, you would have to go up to 12, 13, 14, or 15 inches, and then they could only be made of the wedge or bar form.

The CHAIRMAN: There is no doubt that if you increase the power of your guns so as to require plates of such a thickness to resist their shot, it would be impossible to manufacture them.

Commander SCOTT: You could not manufacture them of the present form.

LECTURE.

Wednesday, March 25, 1863.

THE RIGHT HON. SIR J. PAKINGTON, BT., G.C.B., M.P., in the Chair.

IRON-CLAD SEA-GOING SHIELD SHIPS.

By CAPTAIN COWPER PHIPPS COLES, R.N.

MR. CHAIRMAN, LADIES, AND GENTLEMEN,

AT this moment, when the reconstruction of our Navy occupies so important a place in the minds of all who are interested in the welfare of the country, I hope that no apology is needed for entering into the subject.

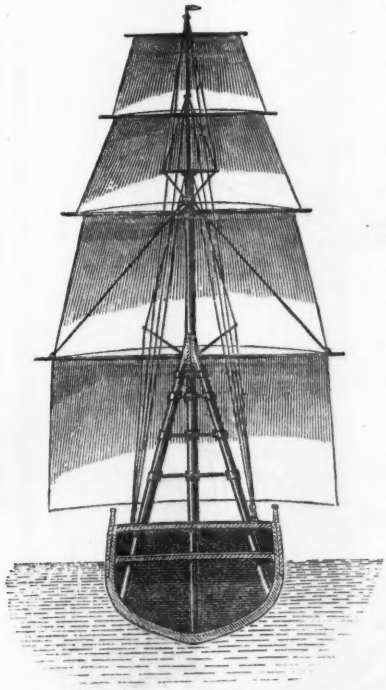
On the 29th June, 1860, I had the honour of delivering a lecture at this Institution, in which my views relative to the construction of Iron-cased Ships of War were first brought before the public, and since that time the progress of events has done much to confirm them, for during the short period that has elapsed since those remarks were uttered, the construction of line-of-battle ships and large wooden men-of-war may be said to have been entirely given up —not only by this country, but by all the maritime nations of the world—and the necessity of having armour-plated ships has been so fully recognized by all that they are everywhere to be found, building or built, of sizes varying from 7,000 to 700 tons. The nature of these ships and the qualities most essential to their efficiency are still open questions, and it is upon their consideration that I now propose to enter. At the time of delivering the lecture to which I have referred I contented myself with giving a general description of my principle of iron-cased shield-ships, but, though the masts were then

placed, I did not go into the details of the rigging and general equipment; for I felt that, as the shield principle was entirely novel, it was only by degrees that people's minds could be brought to look upon it as applicable to a sea-going ship possessing all the qualities required for a man-of-war.

On the present occasion I will go more fully into the matter; and now that the adoption of this principle has solved the problem as to working guns at sea far heavier than any contemplated at the time of my lecture, I shall endeavour to show that it has other advantages which peculiarly adapt it for sea-going vessels of all sizes.

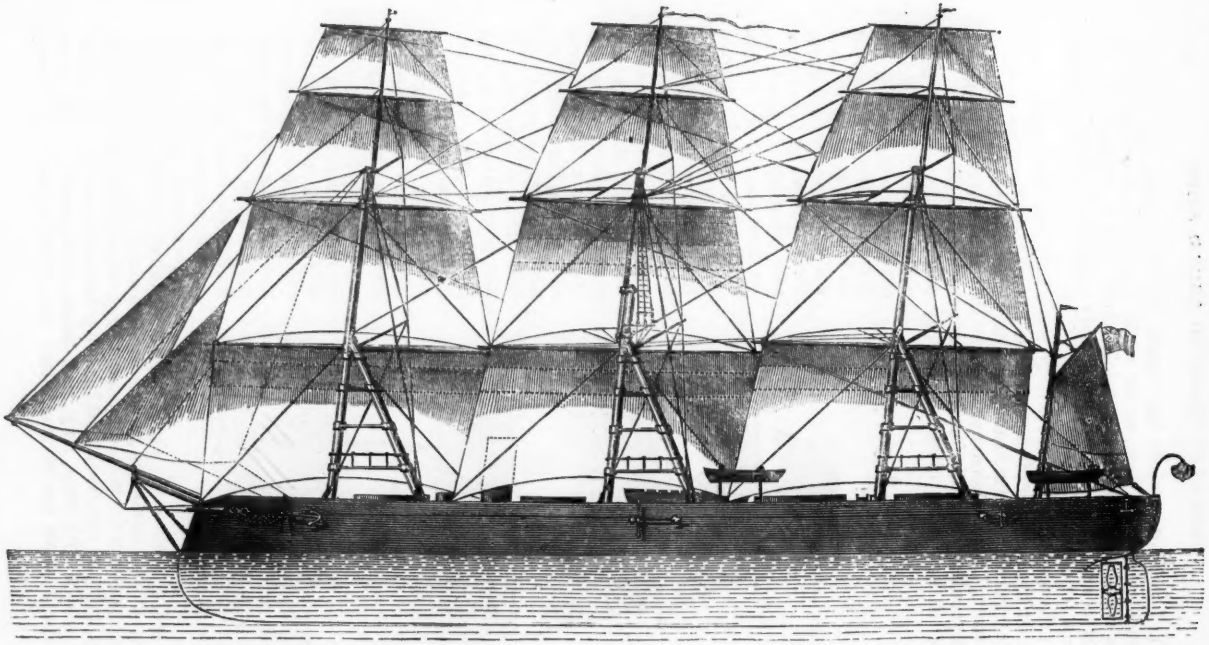
As it has been often erroneously asserted that shield ships could never be efficient sea-going vessels, from the great difficulty which would be found in masting them, I will commence by explaining the way in which I overcome this difficulty. Indeed, so far from there being a difficulty, they can be masted with the greatest ease, and the system which I propose to apply to them, and which can be used in any other description of ship with very great advantage, will enable them when under all plain sail, whilst they retain the same weights, to spread one-half more canvas than if rigged according to the old method. It may, therefore, be fairly assumed that they would have under canvas a proportionate advantage in speed. (See Figs. 1 and 2.)

FIG. 3.



The principle itself may be shortly described as the substitution of rigid iron tubes, for the lower rigging, thus forming with the masts a tripod, and will be easily understood from Figs. 1 and 3, which represent a shield ship of nearly the same tonnage as the "Defence." Fig. 4, represents the ship prepared for action. The top-gallant masts and yards have been struck and stowed either on deck or between decks (the mode of doing which I shall defer describing to a future occasion), nothing being left aloft but the iron tripod lower masts with their long mast-heads, or topmasts. The lower and topsail yards are of iron, fitted with Cunningham's or ordinary

FIGURE 1.



Shield Ship under plain sail, with Tripod Masts, spreading 32,456 square feet of canvas.

Note.—Main Topmast is here fidded, as may be, if preferred.

Note.—Although this ship is shown with a fourth mast, a large spanker may be set on the mizen mast, instead of the smaller one on the jigger mast.

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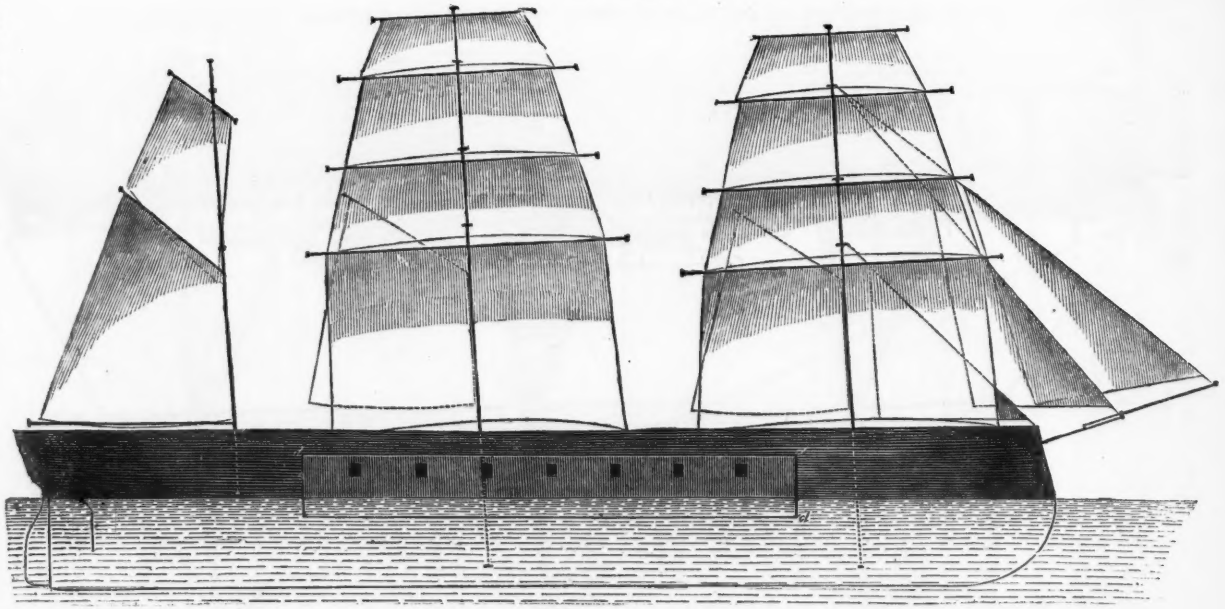
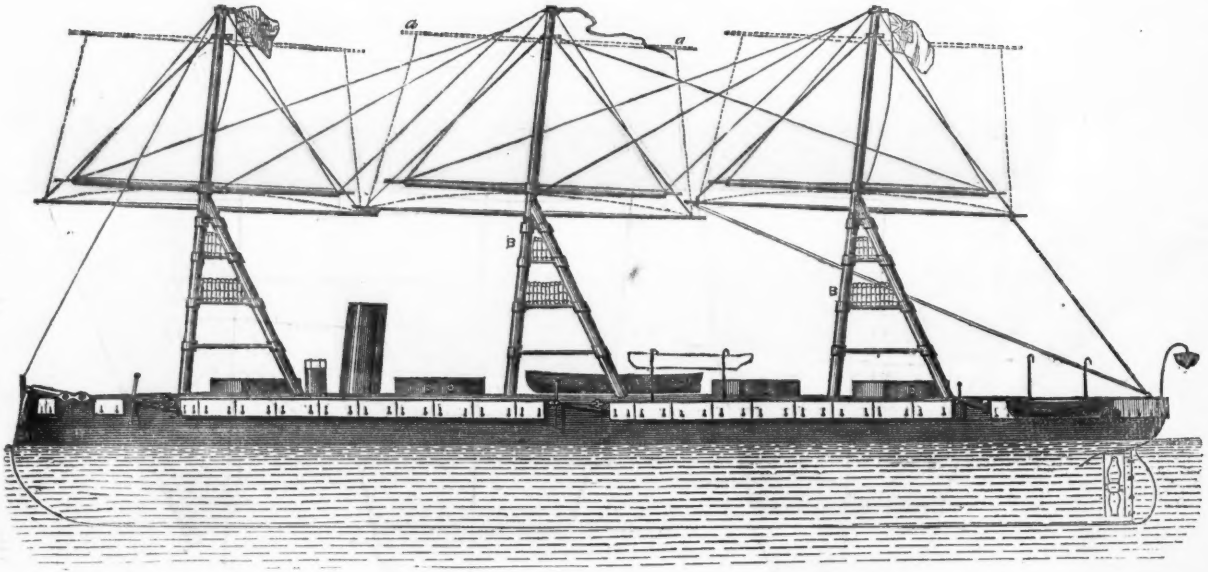
FIGURE 2.



"Defence" under all plain sail, spreading 22,251 square feet of canvas.

N.B.—The shaded portions, *d*, *d*, *d*, *d*, are covered with armour. Broadside, seven 68-pounders.

FIGURE 4.



Shield-ship, with a broadside of eight 300-pounders, prepared for action, with her yards braced fore and aft.

topsails, which, when the ship is going into action, can be either rolled up or set without exposing a man. If there should be a breeze, the topsails could be kept set with the yards braced fore and aft, and would tend to steady the ship with great advantage to the precision of fire.

The following are the advantages I contemplate from iron tripod masts:—

1st. From there being no lower rigging, the great training powers of the shield are not interfered with.

2nd. There being no lower stays, the yards can be braced nearly fore and aft, or in a line with the keel, enabling a ship so rigged to set her square sails when under steam, when with the present rig she would be obliged to keep them furled. On steaming head to wind, the yards being braced fore and aft, and there being little rigging or tophamper on the topmast there would be but a small resistance to the wind.

FIG. 5.

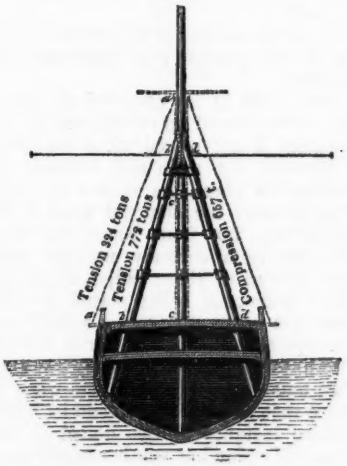


Fig. 5.—*a*, *a*, represents the lower rigging by which the main-mast of a ship would be secured by the old plan, viz., nine six-inch wire shrouds of a side, the cohesion or breaking strain of which is equal to (9 × 36) = 324 tons.

b, *b*, represents one tube or support of the tripod masts, the cohesion or breaking strain of which is equal to 772 tons. But the centre tube or mast, *c*, *c*, would also be supported by the opposite tube, *d*, *d*, for when the ship rolled one would be in tension while the other was in compression, making the comparative support of tubes and rigging as (772 + 657) = 1,429 tons to 324 tons.

3rd. On going into action the topsails can be set or taken in without exposing any of the men aloft, or even on deck. The topsail halyards, and sheets being led down through the cylindrical masts and worked between decks.

4th. When these masts are shot away in action, they would, being of iron, sink at once, as would the yards from the same cause. This with the absence of lower rigging would greatly lessen the chance of the screw being fouled, one of the greatest dangers to which our ships are exposed.

5th. These iron tripod masts will be much stronger and more durable than wooden ones secured according to the present mode by numerous shrouds, they are keyed to each deck. Their relative strength would, I consider, be as shown in Fig. 5, and they would possess the further advantage of being fireproof.

6th. They would afford additional means of ventilation in all weathers.

7th. From their great strength, ships blockading or on other service in heavy weather, would be better enabled to keep the sea and maintain their stations.

8th. They afford great power of defence against boarders by means of the mast platforms for small-arm men, who would be protected by wet hammocks. (See Fig. 4, B.B.B.B.) With the fire from these and from the shields, which are not only shields for the guns but rifletowers, I think there need be little fear of boarders making any lodgment on the decks for the purpose of attempting the much talked of "wedging the shield."*

9th. These masts will better withstand the shock received by the ship when giving another the stem, or when striking the shore.

10th. They will, as already stated, give a greater spread of canvas with less weight than the ordinary masts with rigging. (See Figs. 1 and 2.) Further, all the sails and yards being of the same size, the spare ones will answer for either mast.

11th. The sails are so balanced as to enable the ship to steer and work well, two points of difficulty in the present rig, which are frequently the cause of serious complaints.

12th. The distance between each mast in my proposed rig being governed by the yards not locking when braced up on different tacks, instead of the mizen and mainmasts being placed close together, whilst a great distance is left between the main and foremast as in the ordinary mode, I am enabled to place the centre of effort well before the centre of flotation, so that the ship will work well, particularly in wearing; which is very far from being the case with the iron cased ships rigged in the usual unhandy manner. One great cause of defective working powers of these ships is, in my belief, chiefly attributable to their mainmast being placed too far aft; another is to be found in their not being able to set a sufficient quantity of canvas *in proportion to their tonnage*. This latter is a very grave defect, for it renders an iron ship incapable in many cases of keeping her position in a fleet when under sail, and at a time when it may perhaps be of great importance that as little fuel should be burnt as possible. We have an expensive instance of this defect in the "Defence," during the Baltic cruise. My plan has another advantage, that none of the yards I propose are more than 91 feet long. We lately heard of the "Warrior's" mainyard being carried away: now, I am almost afraid to say the number of the gigantic yards of the present day—yards, some 105 feet long—which I have known carried away, and that not from any want of skill or seamanship, but simply from the weakness consequent on their great length, and I am assured by officers in the Iron Fleet, that during their last cruise to Madeira, when attempting to wear in line-of-battle under sail, from the time some of the ships took going round, they were seven miles apart

* With respect to the operation of wedging the shield, it must be remembered that if wedges are forced in by boarders from above, they can be easily driven up from below, whilst the person doing the latter would be under cover.—C.P.C.

when reformed on the other tack, and this mainly owing to the rig; I am also assured that the large ships in heavy weather could not wear.

13th. The topsail yards can be lowered down on the lower yards in action, and the two lashed together, so that if one is shot away it will be kept aloft by the other.

14th. The last, though not the least, advantage to be derived from the adoption of these tripod masts would be the great saving which would be effected in the expense annually incurred through the enormous deterioration in the rigging of those men-of-war which it is thought necessary according to the present system to keep ready for service in the Steam Reserve. Ships with these tripod masts would always be comparatively ready for sea, and whilst their perishable sails, and running rigging remained stowed away below, nothing would be exposed to the mercy of the elements but their iron masts and yards.*

Important as my tripod rig may appear for men-of-war, I believe it will be found equally important for our mercantile marine. Where great advantage will arise from the saving of wear and tear of rigging, of manual labour, and of loss of life and property.

Fig. 5 shows its relative strength; my mast, indeed, is secured as when heaving a ship down (viz.), by shears; and it is well known what an enormous strain a mast so secured will bear. It has to be remembered that with rope shrouds a mast is only sustained on one side (unless the vessel is dead before the wind), but the tripod masts will receive support on all sides—for whilst one portion of the structure is in tension the others would be in compression—so that each portion of the structure would be doing its work towards resisting any strain that may be brought against it—whether from pitching, rolling, or any other cause. From this great strength I conclude it will be impossible for a ship to lose her lower masts from the elements.

It is well known that being dismasted is one of the most frequent causes of ships being lost or deserted, and that the annual loss of life and property is something fearful to contemplate; and even when a dismasted ship is picked up and saved by another, her cargo is frequently ruined from the water which has poured into her whilst lying unmanageable in the trough of the sea.

It has also to be considered that our clipper ships, after a run to China, often require a thorough outfit, if not an entire new set of lower rigging.

Change of climate and temperature often endanger the masts of ships from the effect produced upon the rigging, whilst change of climate would have no effect upon these iron tubular tripod masts; and I think we may reasonably expect they would last as long as any first-class iron ship that they may be placed in.

It may be said that it is necessary for a mast to have some play, and that these tripod lower masts would be too rigid. That argument might hold good with wooden masts, but it is well known that if an iron mast has play the rivets would work loose and eventually destroy

* The men go aloft by means of Jacob's ladders.—C.P.C.

the masts, so that the more rigid an iron mast can be made the more secure and durable it will be.

Having thus far described my method of masting iron-clad sea-going vessels, before entering into further details, I will say a few words upon the armour-plated ships afloat and building; for, as the problem of iron-cased ships becomes more developed, it appears to me of the very greatest importance that we should impartially consider the efficiency of these ships as engines of warfare in all their bearings, which we may consider depends upon—

1st. Their offensive or destructive powers.

2nd. Their defensive or resisting powers.

3rd. Speed and sea-going qualities (which also may be said to belong to the two former).

4th. Light draught of water and handiness in steering.

The present transition state of Navies, and the great progress which has been made in the construction of large guns, especially in America, leave but little doubt that we are as certain to pass from 68 to 300-prs. as we were from 32's to 68's, when iron-clad ships became a matter of necessity. This conviction has induced me to enter fully into the comparison of iron-clad sea-going ships, with broadside ports, that cannot carry these large guns, and shield-ships that can. The comparative destructive powers of these vessels must be computed from the actual weight of broadside thrown from guns protected by armour-plates; and to make this comparison as clear as possible I have separately compared the "Prince Albert," shield-ship, with four different classes of iron-clad vessels with broadside ports. An examination of Plate x, Tables A and B, will enable us to arrive at some

TABLE "A."—Showing the comparative tonnage and fighting powers of Shield Ships and Ships with Broadside Ports.

NAME.	If partially or wholly Cased.	Thickness of Armour Plating.	Length.	Beam.	Draught of Water.	No. of Men.	Guns in One Broadside protected by Armour.	Weight of One Broadside in lbs. from Guns protected by Armour.	Tonnage.	Speed.
		In.	Ft.	Ft.	Ft. In.			lb.		knot
DEFENCE (*Guns in Broadside Ports.*)	Partially	4½	280	54·2	25 6	455	5 68-prs. 2 110-prs.	560	3720	11·3
PRINCE ALBERT. (*Guns in Revolving Shields.*)	Wholly	4½	240	48·	20 0	160	3 300-prs. 2 110-prs.	1120	2529	11·4
VALIANT. (*Guns in Broadside Ports.*)	Partially	4½	280	56·3	25 2	600	12 68-prs. 3 110-prs.	1146	4063	11·7
PRINCE ALBERT. (*Guns in Revolving Shields.*)	Wholly	4½	240	48·	20 0	160	3 300-prs. 2 110-prs	1120	2529	11·4
WARRIOR. (*Guns in Broadside Ports.*)	Partially	4½	380	58·4	26 2	704	13 68-prs.	884	6109	14·3
PRINCE ALBERT. (*Guns in Revolving Shields.*)	Wholly	4½	240	48·	20 0	160	3 300-prs. 2 110-prs.	1120	2529	11·4
FAVORITE. (*Guns in Broadside Ports.*)	Wholly	4½	225	46·9	21 11	160	2 68-prs. 2 110-prs.	356	2186	10·8
PRINCE ALBERT. (*Guns in Revolving Shields.*)	Wholly	4½	240	48.	20 0	160	3 300-prs. 2 110-prs.	1120	2529	11·4
ROYAL SOVEREIGN.* *Converting into Shield Ship.*	Wholly	5½	240	62·0½	23 9	200	5 300-prs.	1500	3963	12·2

* This ship being a conversion of a line-of-battle ship into a floating battery, no comparison has been made between her and other ships. Her deck will be covered with *inch* iron, being *double* the thickness of any other ship's deck.

TABLE "B."—Armour-plated Ships with Broadside Ports, Afloat and Building. Showing the No. of Men, Draught of Water, Tonnage, and Weight of Broadside from Guns protected by Armour.

NAME.	If partially or wholly Cased.	Length.	Beam.	Draught of Water.	No. of Men.	Guns in One Broadside.	Weight of One Broadside in lbs. from Guns protected by Armour.	Tonnage.
		Ft.	Ft.	Ft. In.			lb.	Tons.
Achilles	Wholly	380·	58·3½	26 9½	704	13 68-prs.	884	6097
Agincourt	„	400·	59·3½	26 2	704	13 68-prs. 4 110-prs.	1324	6621
Minotaur	„	400·	59·3½	26 2	704	„	1324	6621
Northumberland ...	„	400·	59·3½	26 2	704	„	1324	6621
Black Prince	Partially	380·2	58·4	27 0	704	13 68-prs.	884	6109
Warrior	„	380·2	58·4	26 2	704	„	884	6109
Hector	„	280·	56·3	25 2	600	12 68-prs. 3 110-prs.	1146	4063
Valiant	„	280·	56·3	25 2	600	„	1146	4063
Prince Consort ...	Wholly	273·1	58·5	26 7	600	12 68-prs. 4 110-prs.	1256	4045
Caledonia	„	273·	58·5	26 7	600	„	1256	4045
Ocean	„	273·	58·5	26 7	600	„	1256	4045
Royal Alfred	„	273·	58·5	26 7	600	„	1256	4045
Royal Oak	„	273·	58·5	26 7	600	„	1256	4045
Defence	Partially	280·	54·2	25 6	445	5 68-prs. 2 110-prs.	560	3720
Resistance	„	280·	54·1	25 6	455	„	560	3710
Favorite	Wholly	225·	46·9	21 11	160	2 68-prs. 2 110-prs.	356	2186
Enterprise	Partially	180·	36·	15 6	80	2 110-prs.	220	990
Totals		—	—	—	9574	—	16,892	77,117

conclusion as to the comparative tonnage and fighting powers of shield-ships and ships with broadside ports.

In comparing the destructive powers of these ships' broadsides, it has to be remembered that the mere weight of metal, if taken alone, would convey but a small idea of the effect they would produce, as a few heavy projectiles from large guns might destroy a ship, which would receive *little or no injury from a broadside of the same weight of metal, made up of a number of shot of a smaller nature.* But setting aside the great advantages of heavy shot, it is now known that shells, under favourable circumstances, can be made to penetrate iron plates $4\frac{1}{2}$ in., and $5\frac{1}{2}$ in., thick. These shells to be effective must contain large bursting charges, and be of great size and weight, two conditions which necessitate the employment of guns too heavy to be used in ships with broadside ports. In making the following comparisons, I trust, it will be understood that I have no desire to expose the defects of any particular ship, but that I am solely influenced by an anxious wish to add my mite towards arriving at a just conclusion upon this most important subject. The diagrams (done to scale in Plate x) will enable us to compare and contrast the two principles of working guns in broadside fixed ports, and in revolving shields. I will commence with the "Defence." She throws a broadside of 560 lbs., and is 3,720 tons. The "Prince Albert," shield-ship, throws a broadside of 1,120 lbs., and is 2,529 tons, and has the power of fighting half her guns on either side giving her two broadsides of 560 lbs. each, or equal to two "Defences," although the "Prince Albert" is 1,191 tons smaller. Then, this being the case, Ladies and Gentlemen, I am at a loss to know how my noble and gallant friend, Lord Clarence Paget, comes to the conclusion which he has announced to the House, that the shield-ship, when engaged on both sides, would be at a disadvantage, as compared with a broadside ship, for it is obvious, that in weight of broadside when fighting both sides the "Prince Albert" would be equal to two "Defences." But there is another most important point when fighting both sides, and which appears also to have escaped the notice of the noble Secretary of the Admiralty, which is, that the broadside ships, even with their present large crews can only fight every other gun, when engaged on both sides; and, when this is true of 68 and Armstrong 110 prs., what could they do with guns of a heavier calibre? Thus the "Defence's" broadside is reduced to $\frac{560}{2}$ =280 lbs., when fighting both sides, whilst the shield, ship working her guns by mechanical appliances still continues to throw two broadsides of 560 lbs. each. But besides these destructive powers of the "Prince Albert" she draws 5 ft. 8 in. less water and is wholly clad with $4\frac{1}{2}$ in. iron instead of being partially clad as "Defence" is, with two ends, rudder, stern-post, and screw unprotected.

2nd. "Prince Albert" and "Valiant." — "Prince Albert" throws 26 lbs. less in her broadside, but is 1,384 tons smaller, draws 5 ft. 2 in. less, is wholly, whilst the "Valiant" is only partially clad.

3rd. "Prince Albert" and "Warrior."—"Prince Albert" throws a broadside of 246 lbs. more than the "Warrior," is 3,430 tons less, and draws 6 ft. 2 in. less water, being wholly clad, while the "Warrior" is only partially clad.

4th. "Prince Albert" and "Favorite."—"Prince Albert" throws a broadside of 764 lbs. more than the "Favorite," or nearly treble; but although she is 343 tons larger, she draws 1 ft. 11 in. less water.

5th. We now come to the "Royal Sovereign." Her armament will consist of five 300-pounders, throwing a broadside of 1,500 lbs. This ship being a conversion of a three-decker into a floating battery, I will not compare her with any particular ship, but she throws a heavier broadside than any other iron-cased ship we are building. She draws 2 ft. 5 in. less water than the "Warrior," and is 2,146 tons smaller; her speed is estimated at 12½ knots, and she is wholly cased with 5½-inch iron, with 1-inch iron on her decks, whilst none of the others have more than ½-inch.

6th. The cost—but I will defer my remarks upon this point to a later period.

From these comparisons, I think, it is apparent that the shield-ship principle has the following advantages:—

1st. Much greater power of broadside in comparison to tonnage.

2nd. Lighter draught of water—admitting of our present docks being available.

3rd. Greater resisting powers from being wholly clad—or, if partially, with thicker armour.

To have gained these advantages with a lighter draught of water shows that there must be a great saving of weight in the shield principle. This I consider one of its greatest merits, and the explanation is simple,—namely, that in a shield-ship the exposed portion of the side above the water necessary to be protected is reduced to the minimum, the guns being placed in a shield on the top of it. But with a broadside-ship the side has to be carried some feet above the gun and a heavy deck placed over it. It may be supposed that the weight of the shield would be equivalent to that saved in deck, armour-plating, and side; but the small tonnage of the "Prince Albert," and her heavy broadside in comparison with the "Defence" and other vessels, I think, will fully answer this question. It may also be said that there is a great saving in weight in this vessel by having no masts, but the extra tonnage, had she been built for a sea-going ship with masts, according to my view, would have been but trifling.*

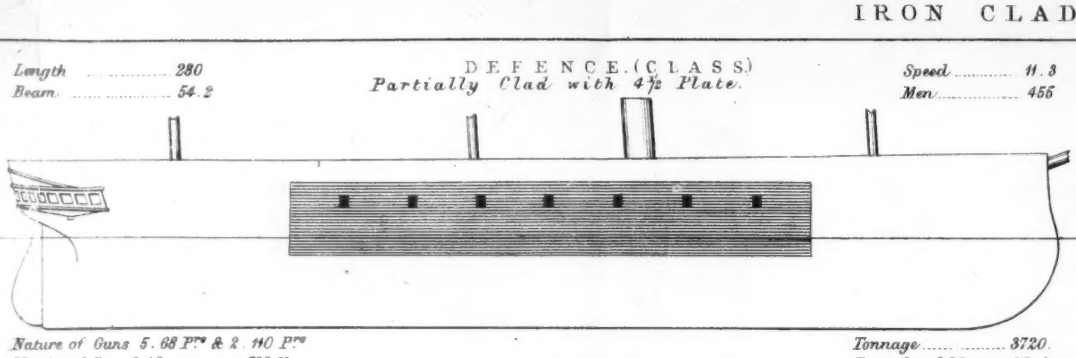
I have so far endeavoured to draw a fair comparison between ships building of different tonnage on the shield principle and built or building on the broadside system. But now let us take a vessel of the broadside port system and compare her with a vessel of exactly the same dimensions and tonnage fitted on the shield principle. I cannot do better than take the "Favorite," for although there was for some time a mystery about her, we have heard much of her

* It must be remembered that a small portion of the difference of tonnage between the "Prince Albert" and the "Defence," would be sufficient to give the former all necessary sea-going qualities. The opponents to my system take every advantage of this vessel not being constructed for a sea-going ship, but from the first I have strongly advocated that she should be.—C.P.C.

DEFENCE. (CLASS.)
Partially Clad with 4½ Plate.

Length 280
Beam 54.2

Speed 11.3
Men 455



Nature of Guns 5. 68 Prs & 2. 110 Prs
Weight of Broadside ..... 560 lbs.

Tonnage ..... 3720.
Draught of Water ... 25_6.

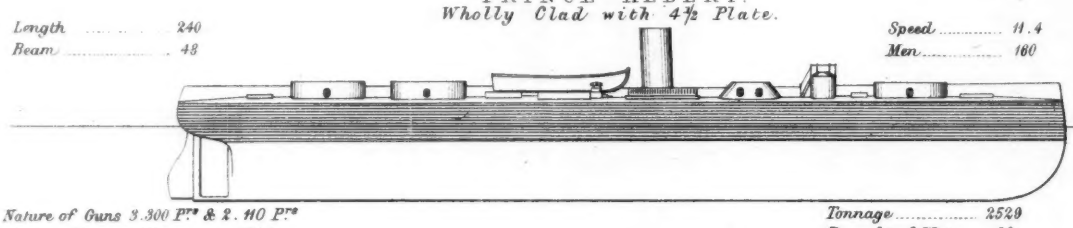
Length .....
Beam .....

Nature of Guns 13. 68 Prs &
Weight of Broadside .....

PRINCE ALBERT.
Wholly Clad with 4½ Plate.

Length 240
Beam 48

Speed 11.4
Men 160



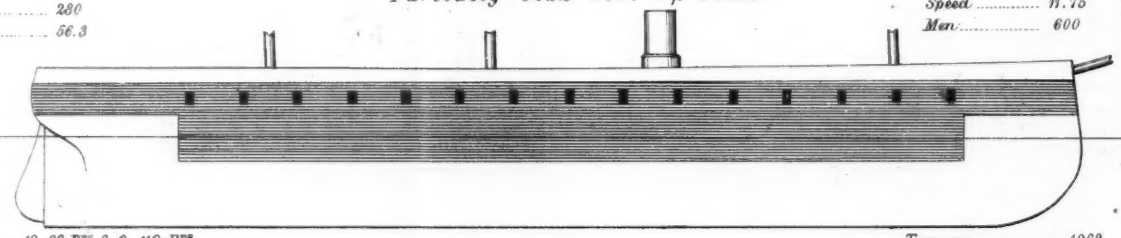
Nature of Guns 3. 300 Prs & 2. 110 Prs
Weight of Broadside ..... 1120 lbs.

Tonnage 2529
Draught of Water ... 20

VALIANT. (CLASS.)
Partially Clad with 4½ Plate.

Length 280
Beam 56.3

Speed 11.75
Men 600

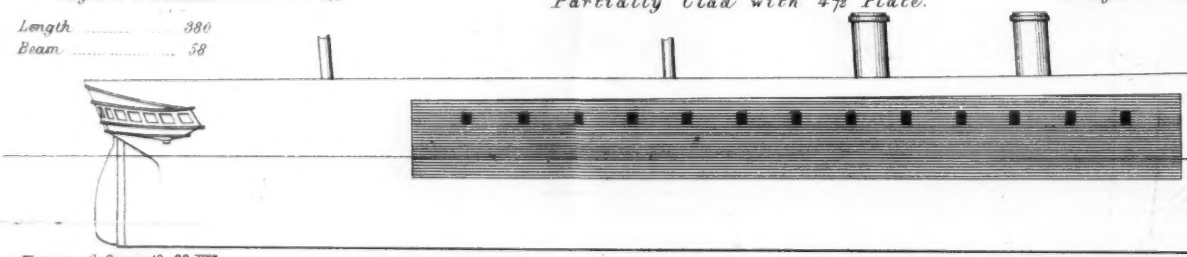


Nature of Guns 12. 68 Prs & 3. 110 Prs
Weight of Broadside ..... 1146 lbs.

Tonnage 4063
Draught of Water ... 25_2.

WARRIOR.
Partially Clad with 4½ Plate.

Length 380
Beam 58

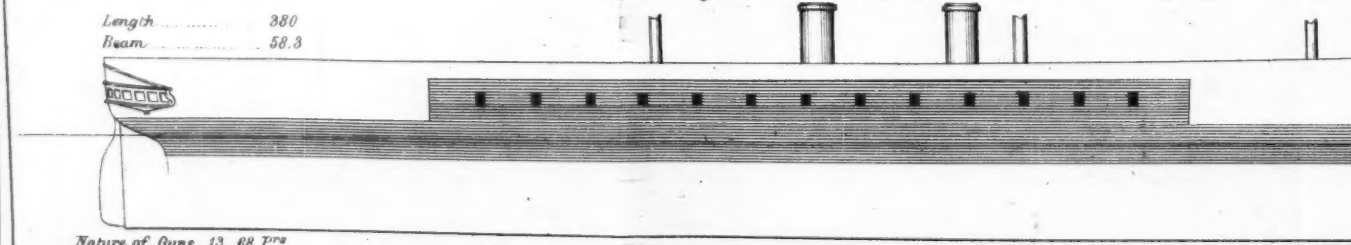


Nature of Guns 13. 68 Prs
Weight of Broadside ..... 884 lbs.

ACHILLES.
Partially Clad with 4½ Plate & Belt.

Length 380
Beam 58.3

Tonnage
Draught

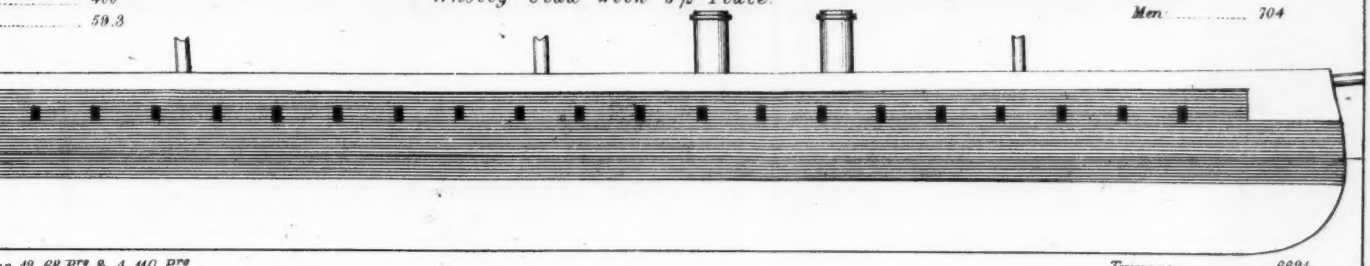


Nature of Guns 13. 68 Prs
Weight of Broadside ..... 884 lbs.

Tonnage
Draught

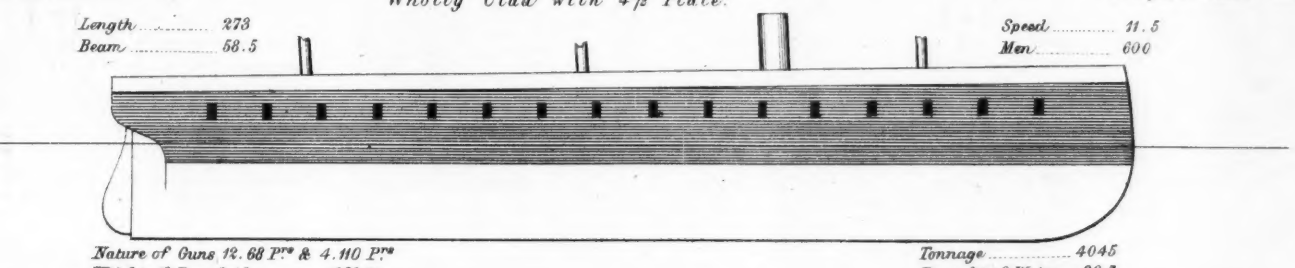
N.B. The shaded portions are covered with Armour. The Guns and weight of Metal as given are of one broadside protected b

MINOTAUR (CLASS.)
Wholly Clad with 5½ Plate.



... 400
... 59.3
Speed ... 14.3
Men ... 704
...s 13.68 Prs & 4.110 Prs
...adside ... 1524 lbs.
Tonnage ... 6621
Draught of Water ... 26.2

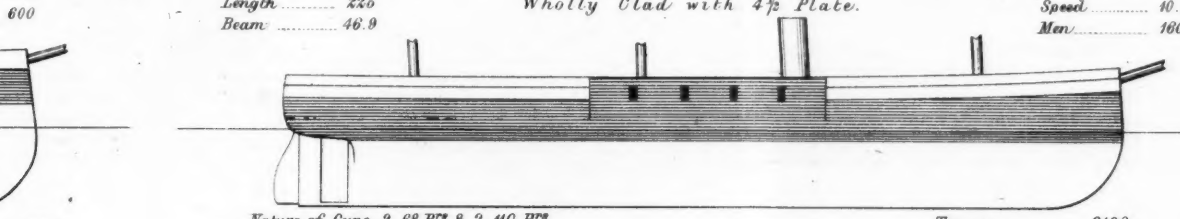
ROYAL OAK (CLASS.)
Wholly Clad with 4½ Plate.



Length ... 273
Beam ... 58.5
Speed ... 11.5
Men ... 600
Nature of Guns 12.68 Prs & 4.110 Prs
Weight of Broadside ... 1256 lbs.
Tonnage ... 4045
Draught of Water ... 26.7

...11.75
...600

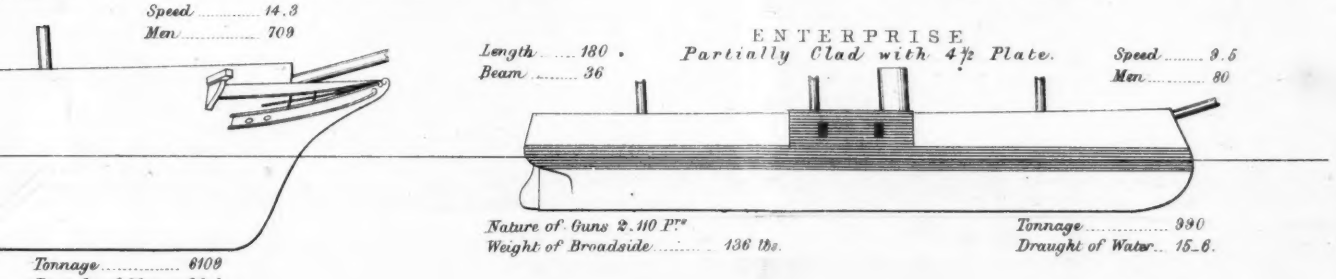
FAVORITE.
Wholly Clad with 4½ Plate.



Length ... 225
Beam ... 46.9
Speed ... 10.8
Men ... 160
... 4063
... 25_2.
Nature of Guns 2.68 Prs & 2.110 Prs
Weight of Broadside ... 356 lbs.
Tonnage ... 2186
Draught of Water ... 21.11.

Speed ... 14.3
Men ... 709

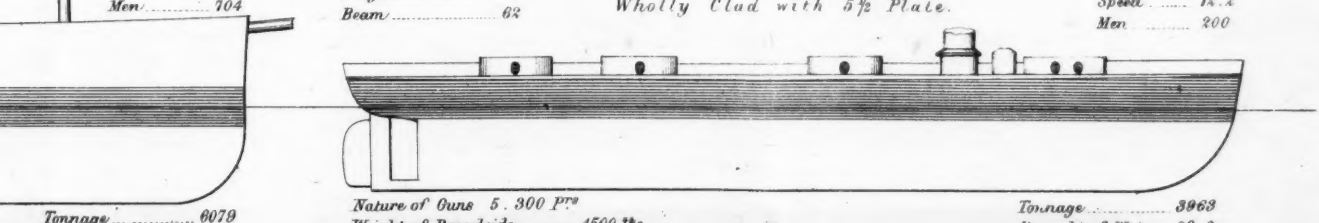
ENTERPRISE
Partially Clad with 4½ Plate.



Length ... 180
Beam ... 36
Speed ... 9.5
Men ... 80
Nature of Guns 2.110 Prs
Weight of Broadside ... 136 lbs.
Tonnage ... 990
Draught of Water ... 15_6.
Tonnage ... 6108
Draught of Water 26_2

Speed ... 14.1
Men ... 704

ROYAL SOVEREIGN.
Wholly Clad with 5½ Plate.



Length ... 240
Beam ... 62
Speed ... 12.2
Men ... 200
Tonnage ... 6079
Draught of Water ... 26_2
Nature of Guns 5 . 300 Prs
Weight of Broadside ... 1500 lbs.
Tonnage ... 3963
Draught of Water ... 23_6.

...de protected by Armour, actually carried by those Ships built, and proposed to be carried by those building.

J.R.Jobbins

lately, and I can find no secret in her construction. But before proceeding with this comparison I think it will be well, in order to prevent mistakes, to give my ship a name; and as there cannot be two "Favorites," although, perhaps, my ship might lay some claim to that name, we will call her, by way of distinction, the "*Naughty Child.*" (See Plates xi and xii.) Now let us suppose the "Naughty Child" to be a vessel of the same dimensions, same scantling, same thickness of armour-plate, and same draught of water, &c., as the "Favorite," the only difference being that the "Naughty Child" is armed with 300-pounders in two revolving shields instead of 68 or 110-pounders in a square fixed box pierced with numerous portholes such as the "Favorite."

I will first consider the sea-going qualities of these ships, they have the same weight, the same spread of canvas, the same engines, and are of the same form and tonnage, their upper *decks are the same height out of water*,* and they are in all respects the same, except that instead of the chief weight of armour-plates and armament being upon the broadsides, as in the case of the "Favorite," the guns and their shields in the "Naughty Child" are in the centre of the ship. In guns and carriages alone, I remove a weight of 40 tons from the broadsides and place it in the centre; besides the armour-plating, backing, and topsides, &c., of the "Favorite" which I work up into the two shields. I must here beg to refer to a paragraph in my former lecture delivered in 1860. "With reference to steadiness in a sea-way, it is clear that the position of the heavy guns and shields amidships is more favourable than that of the armament placed in the ordinary way through vertical sides, and it is unnecessary to enlarge upon the extreme desirability of steadiness of gun platform in a vessel of war. The very act of working guns on the broadsides causes our present large ships to roll several degrees (it must, therefore, affect this smaller vessel in a much greater degree); but in the shield ship, the guns and appurtenances being in the centre, the movement consequent on working them would be comparatively insignificant. Moreover when the muzzle of a gun at the side would be under water, that of a gun placed amidships (see Plate xiii) would be perfectly clear of it, and with a given roll of ship, the former would pass far more rapidly through a greater distance than the latter in describing a similar arc."†

Then looking at the position of those two guns and the broadside ports which must be kept open to take aim through and fight the guns, I feel confident that all experienced seamen and gunners will agree with me when I say that where the "Favorite" would be obliged to close her ports to keep the water out (see Plate xiii), and consequently be unable to work her guns; the "Naughty Child" could fight her's with comparative ease. For seamen all know that when in heavy weather, a good lump of a sea is shipped in through the portholes, it

* 7 ft. 8 in. upper deck out of water.—C.P.C. (See Plate xiii).

† See Journal of the Royal United Service Institution, vol. iv., No. 14, 1860.—Ed.

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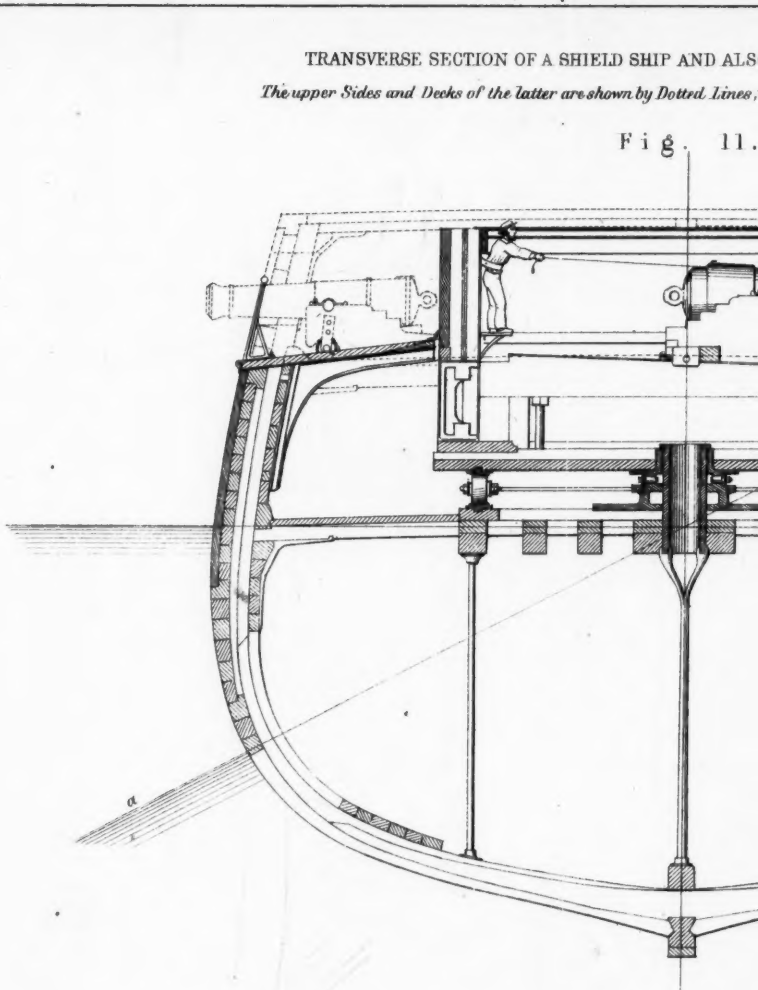
* 7 ft. 8 in. upper deck out of water.—C.P.C. (See Plate xiii).

† See Journal of the Royal United Service Institution, vol. iv., No. 14, 1860.—Ed.

TRANSVERSE SECTION OF A SHIELD SHIP AND ALS

The upper Sides and Decks of the latter are shown by Dotted Lines

Fig. 11.



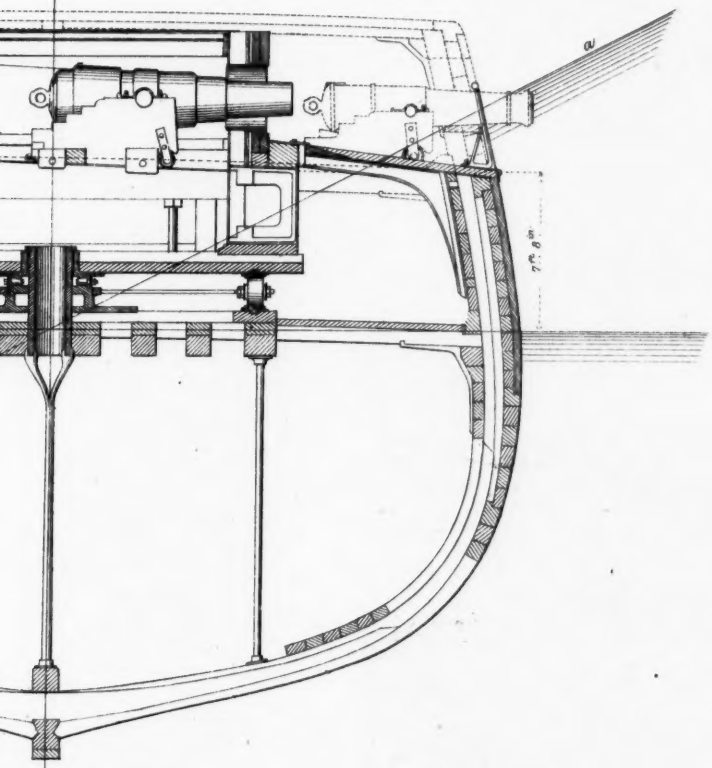
a. a. Water Line when Ship is rolling 26½° showing that t
is 3ft. 9in. above the Water whilst that of a Broadside

Height of Gun Deck out of

SHIP AND ALSO OF AN ORDINARY BROADSIDE SHIP.

by Dotted Lines; the part below the Gun Decks being common to both.

ig. 11.



showing that the Muzzle of a Gun in Shield Ship
f a Broadside Ship is under the Water.

n Deck out of Water 7ft 8in

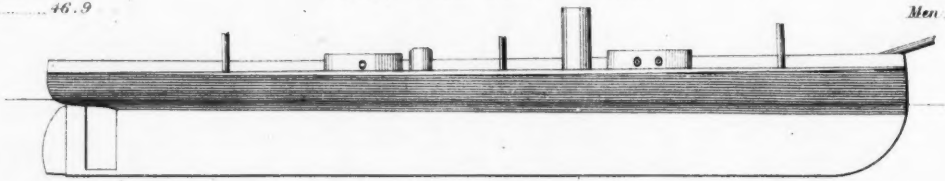
J.R.Jobbins

NAUGHTY CHILD.

Wholly Clad with 4½ Plate.

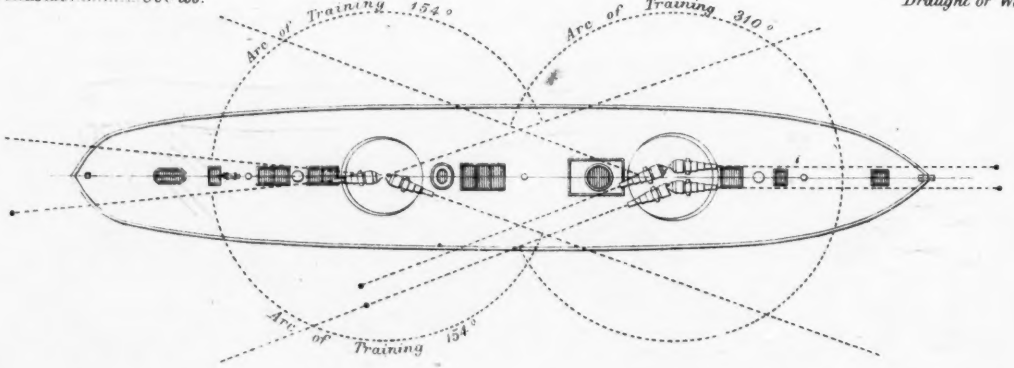
Length 225
Beam 46.9

Speed 10. 8
Men 120



Nature of Guns ..... 3... 300 Prs
Weight of Broadside ..... 900 lbs.

Tonnage 2186
Draught of Water ... 21.11



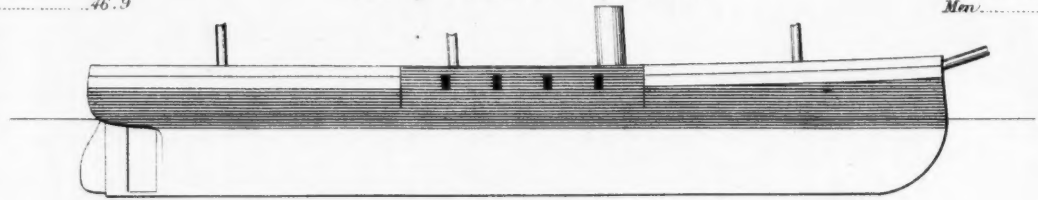
J R Jobbins

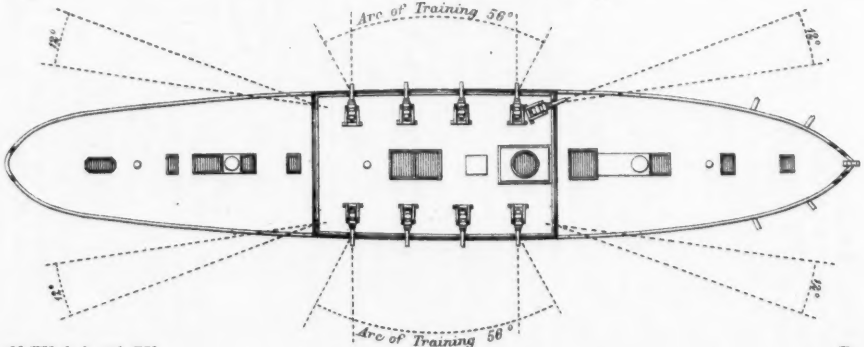
FAVORITE.

Wholly Clad with 4½ Plate.

Length 225
Beam 46.9

Speed 10.8
Men 160





Nature of Guns 2 . 68 Prs & 2 . 110 Prs
Weight of Broadside ..... 356 lbs.

Tonnage 2186
Draught of Water ... 21.11

J.R.Jobbins.

washes from side to side with the motion of the ship, carrying everything before it, and renders it all but impossible to work the guns.

The speed of these ships, we may fairly conclude, would be the same, having the same spread of canvas and the same engines, with the exception of the advantages that I have already shown would be derived from the bracing of the yards with the tripod masts and the little gear aloft to hold the wind.

I will next consider their ventilation;—it will be seen that the "Naughty Child" (Plates xi and xii), has the same area of openings on the upper deck in hatchways and scuttles as the "Favorite." In a gale of wind when both vessels were battened down, the "Naughty Child" would still have the ventilation of the shields, which in fact represent hatchways with coamings 5 ft. high to keep the sea out; the space round the shields in the deck is made watertight by means of a leather flange, assisted by a canvas one in heavy weather battened down to the decks, and a few wedges are inserted from below so as to lock the shield and keep it perfectly steady. Another advantage the "Naughty Child" has, which must not be forgotten, is a clear deck for working her ropes and sails in bad weather; but the "Favorite's" deck is divided in two by her square box, and I cannot see what sort of lead she is to have for her main tack. Then, may I ask those gentlemen who doubt the sea-going qualities of these shield-ships, and I appeal to practical seamen and experienced naval men especially, to give any reason why this "Naughty Child" should not be better behaved in a sea-way than the "Favorite." The weights in the former are lower and better placed, whilst the upper decks are the same height out of water in both, and the capacity of the two ships precisely similar. On more than one occasion my shield ships have been compared with the American "Monitor," the first copy of my invention. I do not admit that there can be any more comparison between her and my sea-going ships than there is between the "Trusty" and "Warrior," and from all I can gather there is not a finer sea boat in the Navy than the latter.

In comparing the offensive powers of the "Favorite" and "Naughty Child" we must consider:

1st. Arc of training, precision, and rapidity of fire.

The ports of the "Favorite," and all ships on the broadside principle, only admit of the guns being trained 28° each way—making an arc of 56°, and when extreme trained, they are worked with much difficulty; they can fire no gun right a-head or a-stern within 9° of the line of keel, and can only accomplish the latter by *transporting* a gun from a broadside port to a small bow or stern porthole cut in the thwartship bulkhead.* But it must be remembered that in a sea-way this is a difficult and dangerous undertaking, and sometimes impossible; at all events it takes time, and although the services of the gun are lost only for a few minutes, if the vessels were equally matched it might turn the tables in favour of the

* Even when the guns are in these ports I doubt their being worked, there not being sufficient space between the gun carriage and side.—C.P.C. (See Plate xii).

adversary. With the shield the range of training is from 50° to 60° each way on the broadside, making an arc of 100° or 120°, the bow and stern shields firing right a-head or a-stern without any transporting of guns, giving a range of 310° training (a glance at Plate xi will show this). No better comparison could be made as to the rapidity and precision of fire of guns mounted on the two principles than the experiments on board the "Trusty" in 1861 showed, when the shield, with a 40-pr., was worked against another gun of the same description and calibre, mounted in a broadside port on an ordinary carriage. Thoroughly drilled men were sent from the "Excellent," and the experiments were carried out under Captain R. A. Powell, C.B., and Mr. Liddell, first gunnery lieutenant of that ship. These officers, of very great experience, were scrupulously exact in their fairness to the two guns.

The cupola gun had a crew of seven men, and the broadside gun a crew of twelve men; great rivalry and emulation ensued between the seamen; those at the gun worked on the old plan, being determined not to be beaten by the gun worked in the cupola. On all occasions the shield gun beat the other in the proportion of three rounds to two, and as His Grace the Duke of Somerset said in the House of Lords, the twelve men working the broadside port gun were fairly beaten and gave in, whilst, I may add, the shield gun's crew were as fresh as ever.* My experience in the "Trusty" tells me that a shield-ship, well handled, would soon wear out the toughest crew of a broadside ship, by continually changing her position, for, as every sailor knows, nothing so rapidly wears out gun's crews as frequent extreme training the guns.

The practice from the shield was as remarkable for precision as quickness of fire, and such superiority had it over the other gun in training, that, on one occasion, seven rounds were fired from it at a gun-boat passing at full speed, when the gun in the porthole could only get one shot. This great advantage was not solely owing to the rapid training of the cupola and working of the gun, but the cupola being above the deck there was always a free current of air passing around the shield, as it were dividing the smoke which passed away from it, whilst it hung to the vertical and continuous sides of the "Trusty," entering the port and obscuring the vision of the captain of the gun worked in the broadside port. The inconvenience from smoke is much complained of in the iron-clad ships, and when I remember how frequently we ceased firing at Sebastopol for the smoke to clear away, I look upon this as one of the most important considerations in action. The precision of fire was also attributed to the fact that the sole duty of the captain of the gun in the cupola, and the winchmen, was to keep the gun bearing on the object, as they had nothing to do with its loading or working, and consequently could devote their undivided attention to it, and that the captain of the gun took his aim by a sight fixed on the top of the shield, which gave him an unlimited

* It must be remembered that the gun is always kept bearing on the object, even whilst loading, and that it can be fired the instant it is loaded.—C.P.C.

range of vision, whilst the captain of the broadside gun took his sight from the rear of his piece, some twelve feet from a very small and contracted port-hole, the area of which was still more reduced when the gun was extreme trained.

Remember, you must hit your adversary to hurt him, and every miss is so much waste of powder and shot, exhaustion of your crew, and loss of time. Therefore let us next consider the target we have to fire at, taking for illustration again the "Favorite" and "Naughty Child." The battery of the former is contained in a square box 67 feet long and 6 feet high, exposing a flat and continuous area of 402 square feet. The "Naughty Child" has two cylindrical turrets, one 22 ft. 6 in. in diameter, and 5 ft. high, and the other 24 ft. diameter, and 5 ft. high, making two surfaces together, of an area of 232 ft. 6 in., between or over which if the shot misses, it passes harmlessly; and if it does hit, if not exactly fair, it would be deflected by the circular form (see Plates xi and xii). In the experiments against the shield in the "Trusty," sixty-nine, 110, and 68-pound shot were fired at it from a gun-boat, the crew consisting of picked seamen gunners, the captain of the gun being Mr. Nash, the crack shot of the "Excellent;" but what was the result, only 44 out of the 69 shots hit it, although the distance was only 200 yards and the water perfectly smooth. The model on the table will best show the punishment received by that shield, and the comparatively little damage done.

But I think it only due to those gunners to explain, that the smallness of the shield, in proportion to the bulk of the "Trusty's" side, made it a most difficult object to hit; and, if this were the case under the most favourable circumstances in steady practice, I think it is unnecessary to dwell further upon the chances of hitting in actual warfare.

In case a shell should get into one of these shields, which appears to me, after the punishment I saw the one on board the "Trusty" receive, almost impossible, the power of that shield *only* would be lost for the time, without any alarm or panic being created in the others; but how different would it be in this square box of the "Favorite," with all the eggs in one basket, consisting of 8 guns, and all the men crowded together? My experience in the Black Sea tells me that one shell of any size (particularly with a bursting charge of 40 lbs.) bursting in this box of guns crowded with men, would silence the whole of the fire for some time, and give her adversary an irrecoverable advantage.

From what has been said, I think that all my hearers who have studied the subject, will agree with me, that guns mounted centrally in shields have so much advantage over those placed upon the broadside, that, even with guns of the same calibre, there would be no equality between ships fitted on the rival principles, but that, supposing both vessels to be equally well fought, the shield ship must inevitably conquer.

But now let us consider the calibre of the guns that can be carried by these two vessels and their comparative destructive powers. The "Favorite's" broadside is limited to four guns, two

68-pounders, and two 110-pounders, equal to 356 lbs., or four 110-pounders, equal to 440 lbs., and these missiles can only damage the "Naughty Child" *by repeated and numerous blows at a very short range.* The "Naughty Child" carries a broadside of 900 lbs. consisting of three 300-pounders, which *ensure penetrating the* "Favorite's" square box even at 800 yards, with shells carrying a bursting charge of 40 lbs., which, I have every reason to believe, will shortly be produced. I will suppose that these two vessels met at sea, and imagine an action between them, the one with a broadside of only 356 or 440 lbs., the other with one of 900 lbs., more than double; why what would be the consequence? I fear the "Favorite" would vote the "Naughty Child" a perfect nuisance and might even feel disposed to avoid her, for I think but a few minutes would suffice to turn the odds most completely against the "Favorite." But the "Naughty Child" would not be merely satisfied with gaining the day, by placing herself so close as to merely ensure not missing the "Favorite's" square box with her 300 lbs. shells, she would be still more perverse and naughty; she would manœuvre so as often to place herself where none of the poor "Favorite's" guns could bear, whilst the whole of her own battery was in full play.

I may here refer to an account of actual warfare from the officer in command of the "Hatteras" when officially reporting the sinking of that vessel by the "Alabama." "Observing that the 'Alabama' was on my port bow, entirely beyond range of my guns, doubtless preparing for a raking fire of my decks, I felt I had no right to sacrifice uselessly, and without any desirable result, the lives of all under my command." The "Hatteras" surrendered and sunk, as I fear would also be the case with the poor "Favorite."

It may be said that it would be hardly fair for the "Naughty Child" to take such a mean advantage of the "Favorite" as to place herself where the "Favorite's" guns could not bear; but, remember all is fair in love and war, and I do not think I over-estimate the odds of a fight between the "Favorite" and "Naughty Child" when I say they would be at least 3 to 1 against the "Favorite." And I would ask any naval man which of these two ships he would choose to be in were he called to take part in a naval action.

Having so far dealt with the general comparisons of shield and broadside port ships I must request your patience while I refer to the construction of vessels to receive the shield.

1st. "The vertical-sided shield-ship," as shown by Plate xiii.

In this plan the armour plates are fixed on the vertical outer side of the ship in the ordinary way, and it was the first method proposed by me to the Admiralty, as follows:—"I propose that these shields should be placed on the deck of a very low iron-sided ship of great length and speed. I am prepared to show further, the working of the cables and other arrangements, and the many advantages which I believe are to be derived from this plan." The vertical or first side, as I proposed for these shield ships, is the one that has been generally adopted and has the advantage of simplicity of construction, giving

greater internal space for accommodation, and great facility in utilizing old vessels, *or the frames of new ones not completed.*

2nd. The cellular or double side as proposed somewhat later by me, with the armour plate placed at an incline.* These sides give greater strength and defensive power, and from the armour plates lying on an incline, with a vertical side exterior to it, they would not have the same tendency to fall off when damaged, or the fastenings broken, as would be the case with the plates attached to the exterior surface of a vertical side, especially when a ship was rolling heavily. But the armour plates being placed at an angle is not of the same importance to shield-ships as to broadside-ships, for the shield-ship from the great training of her guns can always present an oblique side at an angle of from 50 to 60 degrees to the shot delivered from the broadside ship, whilst the latter must lie nearly broadside on, to enable her guns to bear; indeed, the shield-ship's strong point of attack is *from the bow*, for not only does she on that bearing show an oblique side, but the area to be hit and aimed at is also considerably reduced.

When we have to deal with thorough sea-going ships it becomes a great question to what extent they should be plated, whether wholly or partially. We have now the "Warrior," "Defence," and "Valiant" classes coming under the head of partially clad. Splendid vessel as the "Warrior" is and ever proud of her as we must feel, as being the pioneer to the reconstruction of our Navy, yet all vessels of her construction have this defect, that from the unprotected state of their rudder and extremities, at the water line, they are extremely liable to be disabled in action, or, from water getting into the bow or stern compartments, of losing the great desideratum of a fighting ship, viz., speed and handiness. Improvements of course suggest themselves, and I for one have always advocated, in lieu of this mode of partial protection, a belt at the water line, as will be seen from the following explanation of my plans as stated at the Institution of Naval Architects in February, 1861. "The battery or fighting part of the ship is kept quite distinct from the other portion, the men living in the fore and the officers in the after end of the vessel. These ends are built of the ordinary scantling of a first-class iron ship, but an iron band of $4\frac{1}{2}$-inch iron, extending 4 ft. above and 4 ft. below the water-line, is carried round bow and stern, taking in the rudder-head, which is protected by a $4\frac{1}{2}$-inch cylinder, with slotways cut for the tiller."

Again, at a later date, I advocated this system of a band or belt round the water-line at bow and stern in a memorandum relative to a two-shield-ship that was proposed in September, 1861, immediately after the very successful experiments with the shield in "Trusty," and to be designed by the Controller's department, viz.:—

What would be the approximate length, breadth, draft of water, and displacement of a flush deck vessel carrying two cupolas with four 100-pounders, and having the following requirements:—

* See Journal, vol. iv., No. 14, p. 284.—Ed.

1st. Speed—13 knots.

2nd. Height of gun out of water—9 ft. 6 in.

3rd. Vertical height of plating from the water-line 7 ft.; below the water-line 2 ft. 6 in.

4th. The hull of the vessel to be built of the ordinary iron scantling; a sufficient portion to be plated (with 4½-inch iron) to protect engine-room, boilers, magazine, and the working part of the two cupolas, a bulk-head of 4½-inch plating between decks at each extremity of iron-casing. Height between decks. 6 ft. Bow and stern to be plated only 2 ft. 6 in. above the water-line and 2 ft. 6 in. below it.

5th. Beam required for the cupolas 25 ft. in the clear,—as much more may be given as required for stability and displacement.

6th. Weight of one cupola with two guns, about 60 tons.*

Drawings were made of this vessel with a belt, and why she was not proceeded with I do not know, but I have no doubt there was some good reason. In no way do I wish to lay claim to this belt as part of my inventions, for I believe it was proposed at an early period by some of our most eminent ship builders and master shipwrights, and I know it was suggested by several naval officers. However, some time after my proposal was made, we hear of several vessels being laid down on the belt plan, which Mr. Reed describes in the *Times* of May 1st, 1862, as follows:—

"These small craft can only receive partial protection. Recognizing this, I have endeavoured to make the best possible use of the armour which such vessels can carry, and have employed it in shielding, both from shell and from ordinary shot, the following vital points, viz., the engines and boilers, the guns, the magazine, the rudder-head, the steering apparatus, and the whole length of the ship between wind and water" (I need hardly point out to my hearers this is the belt). Mr. Reed goes on to say; "how I do this is a question I must decline to answer for the present, because in this age of sharp naval competition, even a few weeks of silence on such a subject may be of real advantage to us."

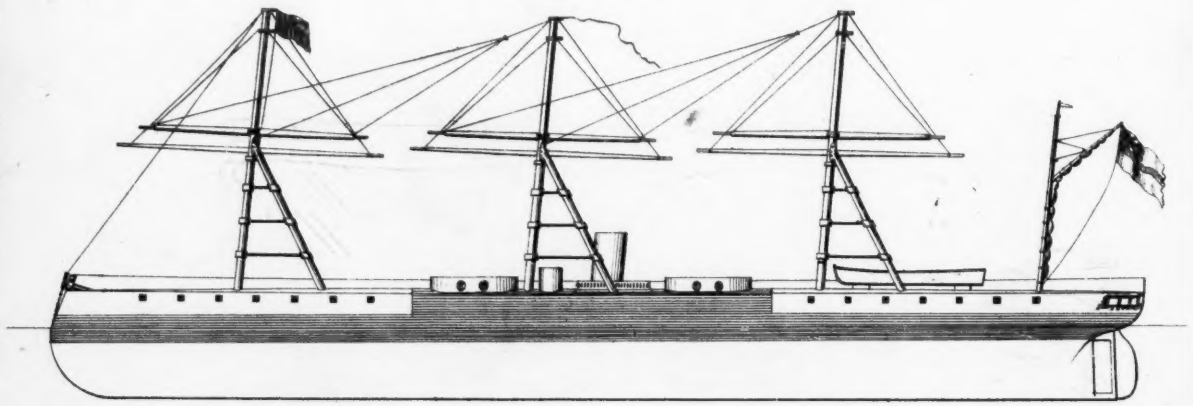
Mr. Reed in his letter also says, "The real danger to which England is exposed at this crisis, is that of letting her pre-eminent power upon the seas pass heedlessly away from her, by neglecting her sea-going Navy, and it is with the view of averting, if it be possible, this calamity, that I have developed my proposals, and placed them before the Admiralty." Mr. Reed gives us to understand that his are the only possible small sea-going iron-clad ships, and consequently the only ones capable of averting the calamity he deprecates, but I cannot admit either that the danger exists, or that his plan is the one to meet it, if it did; and, moreover, now that I know what his mysterious ships are, and looking back to the propositions that have been made relative to iron-clads, I am at a loss to know what portion of these vessels Mr. Reed claims as his plan or invention. The only difference

* These Cupolas were intended for breech-loaders and were to be lighter than I now propose to make them.—C.P.C.

Length ..... *285 Ft*
Beam ..... *52 Ft*

SHIELD SHIP PARTIALLY PROTECTED WITH A BELT.

Speed about ..... *13 Knots*
Men *200*



Nature of Guns ..... *4 300 Prs*
Weight of Broadside ..... *1200 lbs.*

Tonnage ..... *3700.*
Draught of Water ... *24 Ft*

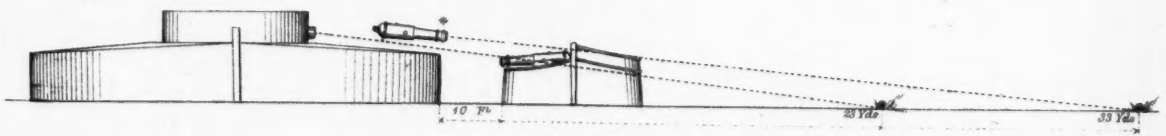
J. E. Jobbins

J. R. Jobbins.

Pl. XV

ROYAL SOVEREIGN AND 80 H.P. GUN BOAT.

Shewing that the Shield Gun can sweep the Gun Boats Deck when close along side and strike the Water at 23 Yds.



* *Position of Broadside Gun in Black Prince.*

J R. Jobbins.

that I can see between his proposals and mine is, that he has discarded my moveable shields, and taken the French plan of a fixed box.

The "Favorite" and "Enterprise" class when first proposed was to have a belt, but now the "Favorite" is to be wholly plated. Some sacrifice must have been made to accomplish this, and I see she has no plating on her upper deck, trusting merely to wood, liable to be set on fire by any molten iron shells, and morever, she has no inner iron skin to keep the splinters out of her sides. The "Enterprise" is on the belt plan, and would carry a broadside of two 68 or 110-pounders. If fitted with a shield she would have one carrying one 300-pounder or two smaller guns. These vessels have wooden bottoms, apparently with a view to get over the grave objection of the fouling of iron bottoms. This is a serious objection, but I feel confident that attention having been drawn to it) the eminent engineers, ship builders, and chemists of this country, will ere long overcome it, and then I fear we may regret having employed the inferior material for these vessels. But to return to the question of wholly and partially plating; considering the great strides we are making in ordnance, I should not think of wholly plating, I would protect the vital parts with thicker plating.

Figs. 1 and 4 represent a shield-ship of about 4,000 tons and 800 horse-power, with a speed of 12 knots, wholly plated with $4\frac{1}{2}$-inch iron and with 4 shields, throwing a broadside of eight 300-pounders: if I wished her to have a greater speed I should give her finer lines, take away two shields, and the plating above the water line at bow and stern, leaving a belt and a sufficient portion in the centre plated to protect the shields, engine, &c., in which case her broadside would be reduced to 1,200 pounds, but would even then be equal to that of any of our leviathans now building (Plate xiv). If, on the other hand, I wished for more defensive power, I should take away as before two shields from the four, and put their plating upon the remaining two, which would then have 11 inches of armour in two thicknesses; and I would use the weight taken off the bow and stern, in increasing the plating of the belt and centre box to a thickness of 7 or 8 inches.

Considering the enormous destructive powers of the great guns now making, I believe, that this will eventually be the mode of construction, for we may go still further with our vessel and reduce her even to one shield, with still greater thickness of plate whilst we retain her sea-going qualities and speed.

Although by way of making a just comparison, I have supposed the "Naughty Child" to be wholly plated, similar to the "Favorite," let it by no means be thought that if I were to build a vessel of her tonnage I should so construct her; on the contrary, I should reduce her plating to a belt and central portion, to take two shields, giving her either more speed or more defensive power, when the odds in the encounter I have imagined would be still greater in her favour.

Another great advantage to be derived from this partial coating, is that the inhabited part of the vessel is totally distinct from the fighting part, "the men living in the fore and the officers in the after

end of the vessel," so that the ship is always clear for action. All naval men know the great inconvenience and loss of time experienced on beating to quarters, where the men (as they do in most of these broadside port ships) live between the guns, particularly at night, when it is necessary to lash up the hammocks and remove the mess tables and stools before a gun can be fired; but in a shield-ship the guns in no way interfere with the hammocks, cabins, or comforts of the crew, and at the beat to quarters, the only thing to be done, is for each man to get to his station as quickly as possible. One watch with the crews I consider necessary for these vessels, is ample to fight the guns, the other watch being held in reserve as boarders or relief. But mark, in these broadside iron-clads, fully manned even as they now are with the best of gunners (such men as it would be impossible to procure on the breaking out of a war), only one-half the guns can be worked when fighting both sides.

Referring again to Plate xiv, it will be apparent that the comfort of officers and men is not lost sight of in the shield-ship, ample space and ventilation being provided for them in the foremost and after portions of the vessel.

We must remember, that wherever an enemy's iron-clad ship can appear on the water, we must, for the protection of our commerce, have one to meet her; and my humble opinion is, that in the course of a few years wooden men-of-war beyond 800 tons will be a source of weakness instead of strength, and the cause of endless disasters, whilst there is nothing to prevent small iron-clad shield-ships from cruizing all over the world. I will take this opportunity to state broadly, that I do not profess to be a shipbuilder. All I lay claim to is being a practical seaman and gunner, who has studied the great question of iron-clad ships, and produced inventions and plans to meet necessities as they have arisen, which, with the assistance of naval architects, I hope yet to prove, not only to be practical but also to be the source of a saving of millions to the country.

There are now four shield-ships building in this country for foreign Governments in private yards, and we shall see, Gentlemen, what models these eminent shipbuilders will produce. As they will be the first vessels fitted and armed on my principle to be tried, I trust that they will prove, as from my own calculations and knowledge of the subject I am convinced they will, that the following advantages will be derived from my inventions:—

1st. The power of carrying the heaviest ordnance that can be manufactured, whereas ships with broadside ports are limited to the present 68 and 110-pounders.

2nd. Throwing a far heavier broadside in proportion to tonnage.

3rd. Rapidity and precision of fire, and an extent of training not to be gained by any other method.

4th. Great speed, less beam being required.

5th. Better sea-boats, from the weights being better divided.

6th. Lighter draught of water.

7th. Shorter and handier vessels for easy turning and docking, &c.

8th. Great spread of canvas and saving of fuel, with the chances of the screw being fouled reduced to the minimum.

9th. Good ventilation and great comfort to the crew.

10th. Greater defensive power.

11th. Lastly, the cost of these ships, particularly where we have the entire reconstruction of our Navy in view, must be taken into consideration. Taking the "Defence" and "Prince Albert" as the two iron ships of the nearest tonnage to each other, we find by Admiral Robinson's paper just published, on "the advantages of wood and iron," that the "Defence" cost £177,478. The "Prince Albert," £113,187. Allowing for the shields £14,400, she will cost £127,587. Now, let us take the tonnage of our Iron-fleet of broadside ships built and building (see Table B), which we find amounts to 77,117 tons, with a broadside power of 16,892 lbs., at a cost of £4,547,382, and compare it with the tonnage which would carry the broadside weight of metal in shield-ships. It may be said that the "Prince Albert" is not a sea-going ship, and I will therefore take my data for this calculation from the "Naughty Child," which I suppose to be precisely of the same tonnage as the "Favorite." She would be 2,186 tons, and would throw a broadside of 900 lbs., or 1 lb. for every 2·4 tons. Therefore, it would require 40,540 tons in shield-ships to carry an armament that would throw an equal weight of broadside with the ships now built or building on the broadside principle. The "Prince Albert" costs £50 per ton, and allowing the same for the other shield ships, we should have £2,027,040 for their expense, being £2,540,342 less than the estimated cost of the ships now building or built as broadside-ships. To be added to this is the saving in maintaining these two fleets, one of 77,117 and the other of 40,540 tons, besides the wear and tear, greater amount of fuel, masting, and sails, &c. I need hardly point out that the fleet of smaller tonnage requires proportionately fewer men; however, let me here state that I am by no means an advocate for reducing the personnel of the Navy, for I believe any reduction on that point would be false economy; but it may naturally be asked, then, what are you going to do with your 70,000 seamen? Time will not admit of my entering now into this question, but I hope to prove a permanent saving to the country on this head at a future time. Apart from the above considerations, a matter of even greater importance is at issue. The great draught of water of these enormous and unwieldy ships with broadside ports renders it indispensable that our docks and basins should be reconstructed to receive them. They are, for the same reasons, rendered incapable of entering many foreign ports, or approaching, if needs be, within an effective distance of an enemy's coast; whereas, with the light draught of water, and the smaller dimensions of shield-ships, no such objections present themselves. For such ships the existing docks in our Government Establishments are large enough, and in time of war those of our merchant yards would be available if required.

It is with some diffidence that I make these assertions, and as it were throw down the gauntlet to the broadside system, but I am encouraged to do so by the knowledge that the criticism they will receive within these walls will be of such a nature as can but lead to the development of the great question of an iron-clad fleet.

I take this opportunity of expressing my thanks to my brother

officers, professional and other gentlemen who have pointed out to me defects, and given me their kind aid, advice, and assistance; indeed, I see one gentleman present, who not only gave advice, but substantial aid when I was hard pressed on the miserable pittance of a Naval Captain, to carry out my inventions. No words can express my gratitude, and now that, thank God, I have so far succeeded as to be enabled to spread more sail, without being brought lee-gunwale under, I will not, should health and strength be spared me, slack, tack, or sheet, until I have weathered the difficulties with which I still have to contend.

In conclusion, I would beg to express my gratitude to the Council for having given me this opportunity of explaining the development of my System of Arming and Masting Iron-clad Ships, and to you, Ladies and Gentlemen, for your kind and patient hearing.

Sir J. Pakington.—It is, I believe, arranged that there shall be no discussion on the present occasion upon the paper we have just heard read, but that a meeting will be held in this room for the purpose to morrow evening, at half-past eight o'clock. But I trust you will all agree with me, that notwithstanding this arrangement, we ought not to separate without passing a vote of thanks to Captain Coles for the interesting lecture we have just heard; and I feel equally confident that you will agree with me that we cannot possibly regard the exertions of Captain Coles on this subject without feelings of respect and gratitude for the zeal, ability, and perseverance he has devoted to this question—a question we must all feel is day by day growing and increasing in national importance. I therefore propose, and I am sure you will cordially join me in giving a vote of thanks to Captain Coles for the able and interesting lecture he has just given us.

Thursday Evening, March 26th, 1863.

The Right Hon. Sir JOHN PAKINGTON, Bart., M.P., G.C.B., in the Chair.

DISCUSSION ON CAPTAIN COLES'S LECTURE ON SEA-GOING SHIELD SHIPS.

The Chairman: Perhaps you will be good enough, Captain Coles, to give us this evening a little summary of your lecture, so as to give us a start.

Captain Coles: Mr. Chairman and Gentlemen, I can give in a very few words a summary of my lecture. It is simply this,—that I do not advocate Captain Coles's principle against Mr. Reed's, or any other principle whatever. The question, I believe, is merely this: central armament in moveable turrets *v.* broadside armament on the broadside; and what I consider to be the superiority of the principle which I advocate is, that the central method enables a ship to carry a greater armament in proportion to her tonnage—consequently, you have less draught of water a smaller and handier ship. I think I need not detain you by going through the various points and advantages which I explained in my lecture, for I believe that is the whole pith of the question (viz.), which of the two modes of arming the ship is the better? As I said yesterday, I do not profess to be a shipbuilder, nor do I profess to go into the question of the form of the ship. I confine myself to the matter of the armament in proportion to the size of the ship, and it is a question with a certain size of ship whether you cannot carry a heavier broadside on the central position than on the broadside system. I think I may say I am now perfectly ready, or rather, the central armament is perfectly ready, to receive any broadsides from the broadside system.

Commander Scott: As no person seems prepared to rise at the present time, I think it is only due to those officers who, like myself, hold that the fighting of guns upon the broadside is superior to the cupola principle, that I go into a few of the facts and figures brought forward by Captain Coles; and in so doing, I hope I shall express myself in a most friendly manner, and in every way in the tone in which every one cannot but speak about his vessels. I have hastily jotted down a few remarks, being very much pressed for time; and if you will allow me, I will read them, because I am unwilling to miss any of the points, as several particulars that Captain Coles has alluded to, are very important. And first I may say, that any one would naturally hesitate considerably before condemning the cupola, after the very able lecture that Captain Coles has given, and the admirable way in which he has treated the subject; and certainly he has treated it in the very best way in which I think it is possible to do; but if the cupola had only been treated in the best way, without detracting from the advantages of the broadside, it would not have been necessary for me to have said a single word, and to have only brought forward what may be said in favour of the broadside; but this not being the case,

it is necessary to review what he said respecting the cupolas, and to show that he has put cupolas in a very different position to that which I think they ought to occupy. It may, however, be said that my subject is that of naval guns; but, studying naval guns, I was in a manner forced into the difficult and very wide question of naval attack and defence, and by witnessing the experiments at Shoeburyness I received a practical and clear confirmation of the views which I had advanced, and the correctness of the proposals which I had the honour to lay before the Admiralty last year—namely, to place the same weight as that of the usual number of broadside guns in a few large guns in the middle of the vessel, and by taking away the armour from three feet above the water-line at the bow and stern just as Capt. Coles has done in that ship—(I have not put up my own, because I can refer to that, which will be sufficient for my purpose; many members who are now present saw the vessels, and are aware of their similarity in some respects, though not in others),—to be able to add to the thickness of the other plates, and to make a shot-proof covering over at least one deck fore and aft. I also advocated the light living deck placed over the bow and stern of the vessel—(I mention this, because you will see in the end, it has rather an important bearing on the whole question, not as touching myself, but as touching the steps which have been taken in other quarters) —and the flattening the floor, and giving additional keels, so as to obtain increased stability with less draught of water. These principles I brought, as I have just observed, under the notice of this Institution; laying before the members two vessels, one of the Minotaur class, mounting ten Horsfall guns, and another of 2,600 tons, mounting six Horsfall guns "on the broadside." (See Plates viii and ix.) But I did more, for I showed how easily those guns could be worked on the broadside, in casemates, separating one gun from the other, so that no splinters from a shot entering one port, could injure the next gun and crew, and that these casemates would materially strengthen the ship; and I also pointed out that the usual plan of estimating the broadside of a ship by the number of pounds weight of shot thrown was a great mistake. I gave a tabular statement, founded on experiments which had taken place, and showed that the broadside of one of the smaller of those vessels, mounting three Horsfall's, was more than doubly as effective as that of the "Warrior," and the broadside of the other was considerably greater. But this development of big guns is of only recent date, and I believe I was the first to lay any proposal before the Admiralty in a clear form as to the plan of working and fighting them amidships. Having gone thus far, I must either own myself mistaken, and strike my flag at once, or show that the cupola ship is in many respects inferior to the vessel fighting her guns on the broadside, and prove that there is no special reason for taking even "Naughty Boys" into favour. But there are many vessels which are shown here, which embody totally different principles, and I therefore propose to deal with them *seriatim*. The first which I will take are those which have been designated by a gallant admiral as true cupola ships, and which he has defined to be vessels wholly armour-plated, with the hull and guns completely protected. That, I believe, is what he calls a true cupola ship, or the cupola ship dexter.

Admiral HALSTED: My statement with regard to the cupola merely has reference to Captain Coles's exposition of the cupola system. I have not specified anything with regard to the vessel being continuously plated, or plated completely at all.

Captain COLES: Allow me to say, these are the ships that I have lectured upon (pointing to some diagrams); those others are merely diagrams showing the area.

Commander SCOTT: I think they are somewhat important, because they show the cupola as first introduced. All these along the cut-down part of the 3-decker are intended to work two guns, the difference being, that instead of guns on the broadside the cupolas are to be in midships. There is the development of the principle. Cupolas along the ship's length instead of broadside ports.

Captain COLES: You are quite right.

Commander SCOTT: Now I take these vessels, and one sees that they are too low in the water to be good sea-boats. And in going to a warm climate such vessels would be unhealthy.

Captain COLES: Allow me to correct you. Those are the vessels that are proposed for coast defence; these are the vessels that are proposed for foreign service. I have two distinct classes, you see. Those are for home defence.

Commander SCOTT: Then I will turn to your cupolas. The cupola here is instanced as *the* cupola, and the results obtained from it as the proof upon which the value of all cupolas hangs. If this cupola accurately represented the cupolas that are now brought forward, then I at once admit that the cupola is a good system; but if it do not represent what is now brought forward, I may fairly doubt the whole of the deductions which commence upon a wrong basis. Now to proceed to show that this is the case. Here is a model of the cupola which was erected upon that mortar vessel, the "Trusty." It is of the bee-hive shape, and exceedingly small. It was made to mount a small gun, an Armstrong 40-pounder, which name, does not convey a correct idea of the size, for it fired only five pounds of powder. The cupola had a large opening in the rear; and although it had that large opening it was necessary, from the concussion in the cupola, when the gun was fired, to cut a hole in the top; and the cupola remains with the hole in the top. But, there is a much more important difference than this.

Captain COLES: But let me draw your attention to one thing; that those cupolas are not on the same scale. That is on a quarter of an inch, and this is on half an inch scale.

Commander SCOTT: I am quite aware of that.

Captain COLES: People might be misled by what you said. That is a small cupola on a quarter of an inch scale, and this is on half an inch.

Commander SCOTT: Is this a cupola to carry the largest guns? I think you say 300-pounders.

Captain COLES: No, that is a cupola of half an inch scale, to carry two 110-pounders.

Commander SCOTT: But to come to the largest size—the cupolas you have mentioned to carry 300-pounders.

Captain COLES: That is 23 feet in diameter, and this is 20.

Commander SCOTT: How much is it in diameter inside?

Captain COLES: It is 23 feet, minus 4=19 feet.

Commander SCOTT: Nineteen feet. Captain Coles is quite ready to fire a heavy broadside, I am sure, at me; and I can only say, I hope he will have an immense number of vessels to build for any body but our own Government; but I do not think his vessels are so well adapted for sea-going vessels as for harbour defence. However, the "Trusty's" cupola is a very small one, fitted for a breech-loading gun; and it was worked against a gun fired on the main deck, which was also a breech-loading gun; but in the cupola the gun was mounted to recoil up a slide. The consequence was, that on being fired, it recoiled up an inclined plane, and ran out again, therefore the men had not to exert themselves in running the gun out; but the gun fired on the main deck had to be run out each time; and can you be surprised that, under such circumstances, the cupola had an enormous advantage over the gun on the main deck in quickness of firing. Nobody can who understands what gunnery is. But when we come to very heavy guns, Captain Coles, as well as myself, knows well that he must have a muzzle-loader—that he cannot have a 300-pounder gun without its being a muzzle-loader; therefore he is in precisely the same position in firing from the cupola as he would be in a broadside port, but with this serious disadvantage, that in the broadside port there is plenty of space to work the gun; but I am sure that you cannot work two 300-pounders in a cupola which is only 19 feet clear in the round. Again it has been insisted upon that this cupola was clear of smoke. Can any one doubt that a cupola open behind would be clear of smoke? There would be a draught through, and the gun only fires five pounds of powder. But to come to this large cupola. Now, I know it has been said, that experiments have been tried with two 110-pounders in a cupola. It is perfectly true. But what was the cupola that the 110-pounders, with ten or fourteen pounds of powder, were fired from? It was a wooden cupola. Wood, we know absorbs vibration and concussion; had there been iron outside it would have been a totally different thing; and I am quite certain the iron skin inside the cupola as now intended would be found a serious disadvantage in throwing down vibration upon the men. You must remember, if this gun is to be effective—I am speaking of a 300-pounder such as the Horsfall gun—it must be fired with 80 lbs. of powder. If you cannot fire it with 80 lbs. of powder, you had better use a smaller gun, and get a high

initial velocity by a proportionately large charge. It is very well known, that unless you get a high initial velocity you cannot effect penetration. There are a pair of 300-pounder guns put in this cupola. Now, I do not think two such guns can be worked side by side at all. I am aware that two guns are worked in America side by side; but it is under different conditions. In America, using cast-iron guns, they cannot fire a large charge of powder; they cannot get a high initial velocity; and therefore they only have a make-shift, and put these two guns side by side to endeavour to make up for a low velocity by weight of shot; but if, instead of the two guns side by side, you had the same weight in one gun, and a proportionate charge, you would have double the force, and would work your gun more easily. But not only is the difficulty of working the gun in a cupola great, and I am satisfied myself that it cannot be worked with any appliances I am aware of, in the present space, because the recoil produced by 80 lbs. of powder in such a gun is excessive, and even a 68-pounder mounted upon a pivot requires 17½ feet clear, to work it well. You cannot work it with less, and may, therefore, reasonably doubt that a gun which, instead of five tons, is twenty-four, and instead of being fired with 16 lbs. of powder, is fired with 80 lbs., can be fired in such a turret at all. But there is another point about the round turret, which I look upon as a very great objection. On the discharge of the gun the whole of the reverberation would be thrown back again in a focus towards the centre. I am satisfied that effect would be found to take place, and I am very much inclined to think you will not be able to fire the 80 lbs. of powder in these cupolas at all. We come, however, to another point. These guns are to be fired over the deck, and an arc of training round bow and stern is here shown. (See Plate xi.)

The CHAIRMAN: That is another principle. There is the "Naughty Child."

Commander SCOTT: Very well, there is the "Naughty Child." We are supposed to fire 80 lbs. of powder over the deck; and if 80 lbs. of powder were fired over the deck of that vessel, where would the deck be? I believe the concussion would sweep off boats and everything else. But there is a further point as to the large round cupola. In the vessel which I or any other person would design, there would be two light deck howitzers, which would pitch shot down these cupolas, if they have to be open at the top.

Captain COLES: I beg your pardon, they are not open.

Commander SCOTT: You have openings at the top which molten iron or powder can run down; the cupolas are sufficiently open; and I am satisfied that you would get a great many such shot, and an immense deal of damage done to the cupolas; and smoke-balls might be sent down them through the hole at the top, from light guns prepared for the special purpose. But, again, the cupola ship is never ready for action; and if she were suddenly caught by an enemy at night, I believe in the hurry of the moment not only would she not clear away the bulwarks, and let them down in time, but she would be very likely on a dark night to blow her own men away from the front of her cupolas. But there is another serious disadvantage, as it appears to me as a gunnery officer, which is this, that in case of the boarders being summoned, you would have to cease firing, and let your boarders form upon deck; whereas, on the broadside deck, you go on firing until the last instant, until your men step on board, which I look upon as a very important point indeed. But, however, as Captain Coles has now come to cupolas in the midship part of the vessel only, and to precisely what we say, that you must take away weight from the ends, and that you could not carry these enormous masses of cupolas, at the bow and stern, reducing the number now to two cupolas; it is with two cupolas that one has principally to deal. These two cupolas then train over a light deck, which would have to be of enormous strength to withstand the concussion of firing fore or aft.

Captain COLES: It is the same as the "Royal Sovereign"—an inch of iron.

Commander SCOTT: Any one who has been at the proof butt, and seen the effect of the discharges on the ground, and heard the opinions of old officers (many of whom have said to me that their decks have been shaken, and great damage been done when they fired their guns a little in-board), must come, I think, to the conclusion, and as a gunnery lieutenant I must say the same, that the concussion from firing the guns in-board would be terrific, and that with 80 lbs. of powder you would be unable to do it with safety; that is, you would be unable to give these guns any

great amount of training, so as to be able to fire them through these arcs, round the bow and stern. Certainly you would not be able to fire them point-blank; you must fire them with elevation; but what you want is, to be able to fire these heavy guns point-blank, and to fire them rapidly. This, however, represents what I think we have been contending for, or at least what I brought forward, independently of Mr. Reed; however, we seem to have both thought and hit on the same thing; but I believe I may say, that I showed mine, unknown to him, before his was brought before the Admiralty. I do not see any of the officers present; but I showed it to two or three, more than a year since. However, in this cupola vessel the "Naughty Child," is shown the very square box that used to be so objectionable, and it is positively put outside the cupolas. There it is, the same square box that I believe will have to be used, separating the vessel in two, despite the shortening the run for the hoisting topsails, and other manœuvres, with which it is said to interfere.

Captain COLES: The upper deck runs flush with the top of that square box. Allow me to show where you are mistaken. In this ship, the "Favourite," the square box runs above the upper deck six feet. In this vessel, the "Naughty Child," it runs flush with the upper deck. So that your argument about cutting the upper deck in two does not apply to my vessel, and blowing the deck away will apply equally to each when training their guns for the bow or quarter. (See Plate XII.)

Commander SCOTT: I am not defending Mr. Reid's vessel; I have nothing to do with one or the other. I have merely considered the matter here. One or two of my friends—two that I have a respect for—have said that I ought to mention these things, and I am merely representing the opinion of a considerable number of naval officers in what I am now saying. The box is rather lower, so that you get a flush upper deck. Now, in all these vessels we know there is ample space—in fact, more space than is wanted. As to any difficulty in hoisting topsails, any of us who have been on board ship know that it is trivial, and there would be very little top work in action. These cupolas are above a central iron box. Now the sole thing which you have done here is, that you have added the weights of these two cupolas to your iron box, which, if you had continued a little bit higher, would have given you the guns on the broadside, and ample space to work them in. But you cannot train and fire these guns, without being liable to damage your own deck; and I am somewhat inclined to think that, with an enemy alongside, the tripod mast legs would stand a chance of getting an accidental shot. However, the fighting portion of the proposed cupola ship is merely a square box, with two cupolas above it. You can scarcely call that the true cupola principle; for it is fighting the guns in midships. Now the question is, can you best fight these guns midships in cupolas, or at the side? I say that you can best fight them on the side, and that your ship will be much more seaworthy. The proposed vessel which I am obliged to refer to was modified through the suggestion of gentlemen at Liverpool, practical men, who said she was too low; so I put a cable deck on her, and a living deck above. That made her upper deck 22 feet from the water; and if you have got a frigate, to make her a good vessel, you require 22 feet. The "Warrior," as we know, is low in the bow, although an admirable specimen of a vessel; and in spite of what the opponents of partial protection are saying, we are all aiming at partial protection at the present time. However, if that deck be much less than 22 feet from the water, it is not really high enough to make her a good sea-going ship. But she will never carry her guns 25 or 26 feet above the water; and if she did, I believe the "Naughty Child" would be much more uneasy than if she had the guns balanced on each broadside. I need not revert any more to the cupola; but I come to the question of the broadside guns, and really it is a very important question. The Admiralty did not adopt my plan of a few guns in midships, and it would require a great deal of consideration to do so at the present time. We hear of big guns continually; I hope they will be produced; but at the present time there is not a single big gun which is not more or less damaged. I may remark, because it is important there should not be a mistake on the question, what at the present time is very well known at the Admiralty—one scarcely likes mentioning names, however, the "Times" has done so—that Mr. Whitworth's gun is rather unwell in its interior; and the writer might have added, that the Armstrong gun is equally so, and its muzzle is nearly off. So that you have the two large guns in pretty nearly the

same state. There is only one that has passed through the ordeal—that is, our old friend, the Horsfall. That, at the present time, is the only big gun that has stood. Now, as there are no big guns, how is it possible to put a few guns in the centre? This plan of armament has been only recently brought forward; but we have not the guns at the present time; you may say, "Oh! we can make the guns of any size." But the practical difficulty is this. The inner tube is at present of wrought iron, and is encircled outside with coils, also of wrought iron. The metal of the inner tube will not stand the large charges of powder, especially in rifle guns, and I see little hope of getting a rifle gun to stand a very large charge. It may stand a few rounds for target practice; but its endurance will not go beyond. Suppose, however, you put in a steel tube; the steel will not expand as the wrought-iron will, under the strain of heavy charges; and in all probability the internal steel will be breaking while the outer coils are only yielding. When cast-iron guns were attempted to be strengthened, there was no metal with which to strengthen them, because there was no steel at that time that you could trust to; and we know not at the present time of any steel that is perfectly reliable. Wrought iron was therefore put outside; the cast iron went, and then afterwards the wrought-iron hoops. And how can the Admiralty have a few guns in midships, when they have not the guns? Or would it be wise to give over building ships, because they have not the identical thing which people at the present instant consider right? and when we see this, moreover, that in spite of what has been said about wholly protecting vessels, most of those who have well considered the subject have said, that your best vessels—your sea-going vessels—can be only partially protected, and this opinion is more and more gaining ground, how, then, can we with any fairness say, that the Admiralty, or any body of men, have done wrong, because they have built different classes of vessels, when we find that one man thinks one vessel the best, and another man thinks another vessel the best?

Captain BLAKELEY: I rise to order. I think this is not the place to defend the Admiralty; because if the Admiralty is defended here, some person might disagree with the speaker.

Commander SCOTT: I am not defending the Admiralty, I am speaking of them as a body of responsible men, showing the position they are placed in.

The CHAIRMAN: I do not think there is anything disorderly at all.

Commander SCOTT: The Admiralty, if swayed by all opinions, would be just in the position of a celebrated painter. Each person marked the defects which ought to be cured, and had he followed their opinions he would have painted the whole picture out. I trust I have now laid before you fairly, and I hope Captain Coles will give me credit for having criticised fairly, the question of the cupola gun amidships. I have brought forward the broadside plan. He fired a very heavy shot against the broadside; on the other hand, I have shown, I believe, that the cupola is open to attack.

Admiral HALSTED: I wish to make a very short remark on one circumstance which my friend, Captain Scott, pointed out as a defect with regard to the cupola system, which is, that of the necessity of its firing its charges over the deck. I quite agree with him, that if there was any reality in the thing it would be serious, but I do not believe that there is. My experience tells me there is not. In India I have myself fitted out vessels, gun boats, and I have not hesitated at all to fight the guns from amidships over the deck, although not, I admit, with 80 lbs. of powder. And, again, in a more recent instance, and at home, I have seen firing of a similar sort. We fired nearly fifty shots with 20 lbs. of powder, from a 13-inch mortar, out of Mr. Berthon's raft, which had only a deck of two inches in thickness, the seams being simply covered and protected to prevent the caulking from jumping out, by thin iron plates screwed down over them. I admit in that case we fired the charge.

Commander SCOTT: Nearly vertical?

Admiral HALSTED: Oh! no; not vertical; but it was fired at the ordinary elevation—probably at from 30 to 40 degrees of elevation. But Captain Scott has alluded to a circumstance which he and I together looked into, not more than about ten days ago, viz., the state of the ground immediately in front of the proof guns before the butt at Woolwich, where undoubtedly there are elevations and depressions

in the ground. But what was the answer we both of us received there? When my friend, Captain Scott, pointed it out as a proof that the ground beneath the guns was bursting, by being fired over, the answer to that was that the whole ground was rotten, and that it was mere made ground; and there is no great tenacity in ground, that I am aware of, in any circumstances, but still less when it is rotten. Therefore, any application of that circumstance to the case of firing over a solid deck, such as that of the "Royal Sovereign," or any of our proposed cupola ships, especially when covered with an inch of iron, I beg to say I do not consider obtains at all; and he has not been quite happy, I think, as I told him at the moment, in his illustration of it, and I do not think there is anything in his objection. Moreover, my friend, Captain Scott, in order to bring forward this question—at least this particular objection, and to make a point of it, if I may say so—has been obliged to invent a gun, and to invent a charge of powder to fire the gun with. Now, he is perfectly conscious that no such charge as 80 lbs. of powder has been fired out of any gun, and he must know it the better because he is a gunner and I am not. I quite agree with him, that when the 300-pounder, so called, which never was a 300-pounder, the gun of Sir W. Armstrong which burst on the 7th of April—blew its breech out—that that gun while it lasted was always spoken of in the press, and puffed throughout the country as a 300-pounder; but in truth it never was more than a 150-pounder; it never arrived at the rank of being rifled—never obtained a cut from a rifling machine; and that gun certainly could hardly be pointed at as an illustration of a 300-pounder using 80 lb. charges, for its highest service charge was but 50 lbs. "I admit," Captain Scott says, "that the gun has passed out of existence;" and I beg to add that those which are following it, on the same mode of construction—and he knows it as well as I do—are going also. But he speaks of the Horsfall gun coming back again. The truth of the Horsfall gun is, that when it was delivered originally, if he will look at the reports which were made, and which I think he has a copy of, he will find it was not a sound gun; and before the Ordnance Committee fired it at all, they took especial care to take impressions of the faults and defects of the breech, and the depth of them, and so forth, for the purpose of ascertaining whether they did, in the course of using the gun, increase or otherwise. Now, I admit that the flaws have not increased to the extent that they were expected to do; and it is remarkable that they have not; but the gun has gone back to its makers again to have these flaws bored out, and have a fresh breech put into it, if they can do it. We have yet to see if there can be a new breech put in, and if it can be safely used afterwards. But, even with regard to the Horsfall gun, I beg, as a naval officer, earnestly to protest against Captain Scott proposing to arm us with Horsfall guns of 22 tons weight. He may see his way perfectly clear to the machinery that is going to work them; but I believe that instead of gun's crews he will have to invent some separate steam engine to work each gun, and I confess I have not the slightest apprehension as to how it is to be done. If it is proposed, as a mere abstract mechanical proposition, whether we can work a gun by hydraulic power this way, or by steam power that way, I quite agree on the abstract point, that it can be done, and you may exhibit a beautiful model of the thing, engine and all; but as to saying we are going to fight naval battles with such guns, that is quite another thing. You may take the great guns at the Dardanelles, and the guns that knocked down Constantinople three hundred and fifty years ago, as proof that, except in special cases, such guns are impracticable weapons, and I think he should limit himself to practical guns when he proposes this great-gun broadside question. There is also another point with regard to this great-gun broadside question, as compared with the great-gun central system, which he has not chanced to hit upon, unfortunately for his argument. The point was mooted the other day by my friend, Mr. Russell, at another Institution, and it is this, that when these great guns come into broadside use, it is intended that one broadside is to be defended by them as well as another. In that case we shall have a 300-pounder on one broadside, and a 300-pounder on the other broadside, to do nothing more than the work that will be at least equally as well done by a single gun on the central system, working upon both broadsides, with a larger arc of training.

Commander Scott: May I correct a statement that has been made, although it is perhaps unusual to speak again, otherwise a wrong impression will be left?

The gun was fired with 74½ lbs. of powder. That is the charge it was fired with at Shoeburyness; and it is intended, I believe, to fire the same gun with 80 lbs.; at least I have understood so; which would be the proportion they are firing the guns with at the present time?

Admiral HALSTED: No.

Commander SCOTT: Yes.

Admiral HALSTED: What guns?

Commander SCOTT: The large guns.

Admiral HALSTED: The proportion I am speaking of.

Commander SCOTT: The same proportion to the weight of shot.

Admiral HALSTED: I am speaking of the shot itself, not the proportion.

Commander SCOTT: We both mentioned 300-prs.; and with regard to the Horsfall gun it has been mentioned that it had a flaw, it had; because in the forging of large masses at that time there was a difficulty as to getting machinery sufficiently powerful. That large flaw has remained in the gun; and I can assure those who have not seen it, that I have seen the whole of the impressions, and it scarcely appears to have been changed from the time it was tried, up to the present date; and as to any difficulty in boring out the gun or putting it to rights, there is none whatever; but in doing so it will make the bore larger and the shot a little heavier, and therefore its proportional charge will be 80 lbs. of powder.

The CHAIRMAN: You are making a reply rather than an explanation.

Commander SCOTT: I beg your pardon.

Admiral HALSTED; The charge of 80 lbs. is evidently a charge which is to be.

Commander SCOTT: I was only wishing to give an explanation. I did not think the Admiral quite quoted what was said as to the ground at Woolwich. Rottenness implies one thing, the ground being faulty implies another; but the very fact of the whole of it being lifted up at each discharge, and changed in condition, shows the immense effect that firing heavy charges will have. I have nothing more to add.

Captain CROSSMAN, R.E.: I should like to ask Captain Coles one question. I am not a naval officer; but it seems the great advantage of these cupola ships, is in the guns having a great range—360° on that plan. I shall be glad if Captain Coles will kindly explain the mechanical arrangements by which he will ensure these turrets not jamming when the ship is rolling in a heavy seaway. When we look at that ship there, we may imagine what the weight of the turret, with the guns, will be, and how it will jam on each side. It seems to me to be difficult indeed, to make it revolve with the rapidity which will be necessary to bring the guns to bear in the way you wish. That is the only question I wish to ask; if you will explain it I shall be obliged.

Mr. COBYTON: I rise, Sir, with great diffidence, not being a member of this Institution, but having some models in your Museum, illustrative of the principles now being discussed, I should be glad if you will allow me to make one or two observations, suggested by a question that has just been asked. I have for many years been endeavouring to promote the construction of ships upon the principle that you may see illustrated upstairs in my model, and which is adapted just to this very matter of cupolas. My principle is assisted now by the extreme facilities that have been given recently for steering ships. A gentleman was asking just now what means you have in a seaway of ensuring that this cupola shall revolve steadily. My plan is chiefly directed to keeping the guns steady, and shifting the ship. You will see, the construction and form of vessels on my principle is entirely unlike any other, it being intended to go one way towards an enemy, and the other way off, just in the same way as it is intended to sail one way on a wind, and to make stern boards when you are going off the wind. One other fact I will mention with regard to my models. I was, I think, some time before Captain Coles in inventing the mode of supporting these tripod masts. I would ask Captain Coles whether he would not find any advantage in sloping his masts, and giving them an inclination in-board.

Captain COLES: Sloping them? Raking them, you mean.

Mr. COBYTON: Sloping the mast itself; that is, making it rake in every direction.

Captain COLES: That is a problem I really have not been able to solve at present—raking in every direction.

Mr. COBYTON: I am perfectly aware there was a *lapsus linguæ* in the expression

I made use of; but I mean this, and I think you will find the matter is hardly open to ridicule, that the masts sloping that way would have a proper rake, not only as is now the case when going free but also when sailing on a wind; I think it would be found, when your ship was going close-hauled, that you would have a positive advantage by your mast being inclined towards your deck.

Captain COLES: Quite so.

Mr. JEFFRIES, late Madras Artillery: There is one question, Sir, I would wish to ask. It is, that if they fail in making breech-loading guns of the size Captain Coles proposes, how does he propose to load a gun in his cupola? The recoil of the gun would be hardly sufficient, taking that drawing scale as an example, to bring the muzzle into the port. At any rate, the ports are there represented as mere holes for the muzzles of the guns to project from. It seems to me there would be some difficulty in using the rammer out of those ports, supposing the 300-pounder breech-loaders cannot be made

Captain FISHBOURNE, R.N.: I had hoped that some of those gentlemen who had the advantage of hearing the paper read would have obliged us with a little more discussion on the subject. I, unfortunately, was obliged to be absent, and had not that advantage. I must confess I see a difficulty in the recoil. I do not anticipate that there would be any difficulty in getting large guns to stand large charges. I confess we must go in the direction of large charges. I am quite sure of it. I am quite sure of this also, that if you do not go in the direction of large charges you will not get the high initial velocity which you ought to get. As charges are at present used (though they are comparatively small), by being exploded under compression, the tendency is to destroy the gun rather than expel the missile. Now the great object is to get the greatest possible initial velocity with the smallest possible initial pressure on the gun. If that principle is adopted, I am quite sure you will not only get large guns, but you will get very high initial velocities. This will involve us in a difficulty with respect to the cupola and all small batteries; that is, you must have very heavy guns, or you must have a very great recoil. There is no alternative. If you have light guns with large charges, do what you will, you will not be able to control the recoil. You may have machinery, but your machinery will not stand; added to which, you will have complication, and the only way is to come back to the old thing—heavy guns with heavy charges. Weight of gun is the best and simplest way to control the recoil.

Admiral HALSTEAD: With round shot?

Captain FISHBOURNE: No, I do not say round shot. Round shot has its province, and rifle shot has its province; I believe both are useful in their respective provinces. You cannot say that a rifle shot will do what round shot will do, or that a round shot will do what a rifle shot will do. But I must confess that it is one of the difficulties I see in the cupola; because the moment you come to very great recoil, you must make your cupola so very large, and it becomes then literally a broadside gun. It is simply true that you have it in a central position on a turntable. Well, the great point, I think, and that which is of the greatest value, is the turntable. I think it is a great advantage. The turntable might be applied to broadside guns. Captain Coles has alluded to a question of naval architecture, which is another point; that is, that he gets a narrower ship. Now, I believe this is a point that has been utterly overlooked in our naval architecture. To give an illustration of the practical fact. I was speaking to Sir Thos. Maitland, the other day. He said, "I find, that the "Baccante," under the most favourable circumstances, rolled 7°, as compared with the French ships which rolled only 3°—not at sea, but in harbour. Now," he said, "what accuracy will you get at several thousand yards, in a vessel rolling seven degrees? I believe the real history of that is, that the form of the ship was bad; and I believe that is in a great measure necessitated by the burdens that were thrown upon it. Now, the advantage of having a narrow ship, with a central battery, however you may arrange it—I am not prepared to commit myself to the cupola—is, I think, very apparent. If you do not have a narrow ship you cannot have a light draught; and if you do not have a light draught your vessel will be wholly inefficient in many points. Now, I contend, as a coast defence against the landing of an army, it is indispensable to have light draught vessels; but if you have broad vessels with light draught, I say you have infinitely more

uneasy vessels than those which Sir Thos. Maitland was speaking about, which rolled seven degrees, while the French ships that he spoke of only rolled three degrees under the same circumstances; and, I say, you may have superior guns, and you may have superior modes of using these guns in a vessel rolling seven degrees, but she is placed at such an immense disadvantage against a vessel with inferior guns that is rolling only three degrees. So that I say there is an advantage in the narrower ships which Captain Coles proposes to us. I do not see any difficulty, looking at it as a naval architectural question; but, on the contrary, I believe it has that advantage. I said before, that I think there is a greater difficulty with respect to the recoil, and that you will be obliged in the narrow ship to take the whole width of the ship as the measure of the recoil that you will give your guns; for you will have large guns with large charges, and you will have no alternative. The rake of the masts, as has justly been observed by a gentleman (Mr. Coryton), is a decided advantage; but as the vessels are principally intended for steam-vessels, the advantage that would arise from the inclination of the mast, as a sailing vessel, is really not worth consideration; and it would be a serious matter, I think, to give too much rake to masts of the kind that he has proposed adopting, with so very little rigging. No doubt little rigging is an advantage if the masts are shot away; having so little rigging, they would not be so liable to foul the screw. As I have said, I have not had the advantage of hearing Captain Coles's paper, and I am not prepared to say any more on the subject.

Vice-Admiral O'Brien: I think, Sir, in a subject of this sort there seems to be one great point that nobody has ever thought of, which is, the physical effect which these guns will have on the men who are confined in these cupolas, or whatever they may be. That is a point, I consider, of the greatest consequence, which none of these scientific gentlemen seem to have taken into their consideration. I think, Sir, when we talk of 80 lbs., which is very nearly a barrel of powder, to be expended at a charge, we should consider what is to become of the men who are to stand in these cupolas? I say they will be killed by the explosion. That is my opinion.

Lieut. Colomb, R.N.: I should like to ask Captain Coles one question—not so much about his cupolas as about his tripod masts. What would be the effect of the shot striking one of those tripod masts? Would it not carry it away entirely? And when the usual mast is supported by rigging, I do not think one shot would do that. That is one question; and I want to ask about two more things; they are hardly questions. There is one illustration of the effect of the explosion of powder on the deck which has not been brought forward, and that is, the effect of the explosion of powder in earth-work-*embrasures*. I do not think it has been found to produce any inconvenience or disturbance there. Of course we have only had small charges of powder. There is still a third point. I think Captain Coles mentioned in his Lecture, that he approved of iron for the entire construction of the ship, that is, that the bottom was to be of iron, and he did not anticipate much inconvenience from the fouling of the bottom. Now I happen to have looked over, in the last few months, an immense quantity of despatches and orders from officers in command of the fleets from about 1691 to 1770, which was about the time of the introduction of copper; and I could not help being very forcibly struck with the fact, that nearly every letter written by those officers in command mentioned the tremendous inconvenience under which the ships laboured, from the effect of the fouling of the bottom. Now, I think we ought to look a little cautiously to matters of that sort; and if the fouling of our iron bottoms is to take place to any considerable extent, we ought to take some means, if possible, to guard against it, and we ought not to trust entirely to the chance of something being invented to get rid of the fouling.

Captain Blakeley: I should like to say one word on a point of fact. It has been asserted that it is impossible to make guns larger than 300-pounders, I think. Now in America we know that the guns are not only 300-pounders, and 500-pounders, but they have got a 1000-pounder, and they use these on board ships, some in cupolas, and some out of cupolas—guns of upwards of 20 tons. The old United States 11-inch gun weighed 14 tons, and they found no difficulty in using it. Eleven men can use it; the usual crew is nineteen. There is no difficulty whatever about it. With respect to the guns in this country, Captain Scott says the Admiralty had no opportunity of trying any other guns. I beg to say, in 1860 I offered to lend the Admiralty a 700-pounder for two months, on condition that they would use it, and

they refused. I have made the same offer several times, and it is still open to them, next week or the week after, if they choose to have one of the 700-pounders to try. They are in the country. They are existing.

Commander SYMONDS, R.N.: I should like to make one or two observations on Captain Coles's paper if there is time for it, not in any antagonistic spirit, I beg leave to observe. I only take up this position, that there are two ways of arriving at the same point. You observed yesterday, Captain Coles, that a ship with broadside guns could not bring those guns to bear under some circumstances. I forget the angle which you mentioned. Now I have ascertained, and I think there are many gentlemen present who have heard the reports of the trials of two rather celebrated vessels lately, which have been manœuvred by two screws—that these vessels are not only able to attain a very considerable speed, but they have actually the same power of turning on their centre that a cupola has; and therefore if they have that power which I say they have, the broadside guns in such ships may be brought to bear, I will not say as well as yours, but very nearly so. I believe that in a sea-way under average circumstances, the guns—properly fitted heavy guns, I mean—in the broadside of a ship, will be brought to bear quite as rapidly as yours will; and moreover, that I do not think they will be liable to some of the objections which I have heard raised to the cupola. At the same time, I remark—you will pardon me for saying so—that I believe even your beautiful plan may be improved by the application of two screws to your ships.

Captain COLES: I quite agree with you, that rapid turning in all cases is most essential.

Commander SYMONDS: You are liable to the same accidents that all people are afloat. Your cupolas may not always jamb, but they may occasionally get out of gear; and if your cupolas, say two out of five, get out of gear, you would be in a bad or worse position than a broadside ship would. Therefore my observations go more to the value of the application of two screws in general than as against your cupolas. There is one other remark I would make, which is, that you have a very clever and, perhaps, a very capital invention for doing away with a great portion of the rigging. I have some doubts of its success, as the chances are threefold of those masts being struck by shot, as compared with one mast; but I think there is one simpler mode of effecting what you endeavour to produce there, which is, to protect the screw from fouling by the form of that screw. Now I, on my own authority, state that there is such a screw; one of our first mechanics has invented a screw which has been exhibited on several occasions here, and which very many practical men believe in. The only question that remains is, as to the mechanical effect to be produced by that screw, which is a matter for experiment; but of this I am quite sure, that nothing will foul it. So that, to a certain extent, I consider that the objection to single masts with wire rigging is removed. I think that at this period of the evening, as I have not had the pleasure of being able to attend here earlier, I shall not make any further remarks.

Captain COLES: Mr. Chairman and Gentlemen, I must say that I feel at some loss to follow the numerous broadsides, and friendly broadsides, which in the kindest way have been fired at me, I may say, from the truck to the kelson. There is the bottom of the ship fouling, and the firing away of the mast, and taking the cupola in the bargain. However, I hope you will excuse my being very short in my answers, there are so many questions that I cannot afford to expend more words than possible. Therefore should there appear to be any abruptness in my answers, I beg you will make allowance for it. Captain Scott was the first whose broadside I had the pleasure of receiving. He described a vessel of 2,600 tons, carrying six broadside guns, with casemates, and the heaviest guns, I presume, that can be made. Before I answer, I must ask what weight these guns would be approximately.

Commander SCOTT: Without the engine room the vessel is 2,600 tons. The guns may be 24 tons, if they could be made to stand, and they will do it; and the guns are worked, which I did not speak of before, alternately; so that they have the whole length of the deck, if you wish, to recoil over.

Captain COLES: Now it should be borne in mind, that my argument from beginning to end has been with two ships engaging each other, and a heavier broadside in

proportion to the tonnage. If you have to carry six guns, 24 tons on the broadside, that is three on each broadside. That would entail placing six times 24 tons on the extremes of that vessel; whereas, a shield ship to engage and be equal to that one vessel, would do the same work with three guns of 24 tons in the centre of the vessel, instead of six guns of 24 tons on each side of her. With regard to tonnage, when you come to the heavy gun, I think the central armament has this advantage, that you do the same work with half the number of guns. The next thing Captain Scott said was, that my vessels were too low to be good sea-boats; but at another place to-day we heard of vessels of 200 feet, being from five to six feet out of the water, and being considered good sea-boats. Captain Scott also says, that vessels, to be good sea-boats, must be 22 feet out of the water. But what is the height of many vessels, when deeply laden, across the Atlantic? Why, they are not 12 feet out of the water.

Commander SCOTT: I beg your pardon. I spoke of the frigate mounting ten guns being 22 feet.

Captain COLES: A frigate may be 22 feet out of the water, but instead of my vessel being too low in the water, the vessel here described (Plates xi and xii) I think you will find the same height out of the water as the "Favourite." Mr. Reed's vessel, it will be seen, that I take a shield ship of exactly the same tonnage, and she is exactly the same height out of the water. The only difference is, that instead of having the square box in the centre she has two revolving shields. Again (see Plate xiv), I take a vessel of 3,700 tons, her deck is 10 feet out of the water, and her bulwarks would be 14 feet out of the water, with light and buoyant ends, as this vessel would have, and 285 feet long. She has no open port-holes for the sea to wash in, but merely scuttles, as you have in oriental boats, which in bad weather are screwed on. You have no ports open in bad weather when fighting your guns; and I do not see why that vessel should not be a good sea-boat; but at all events I have the opinion of naval architects and eminent ship-builders, who tell me that these cupola ships will be perfect sea-boats, and for this reason. You see, the height of the shield ship for the sea to break over would be this point (see Plate xiii); whereas, the height of the broadside for the sea to break in, when fighting her guns, would be this point (her port-holes) where the sea rushes into the ship, and you cannot get rid of it; but in the shield ship the sea merely washes over the deck and runs off again. We do not mind a little water breaking over our upper-deck at sea; but a sea shipped between decks is fatal to working the guns. A good sea-boat does not altogether depend on her height out of the water, but on her general proportions and the way in which the weight is placed in relation to the centre of gravity. I am not a ship-builder, and will not enter into these matters; but there may be some naval men here, Captain Fishbourne and others, who perhaps will. Captain Scott mentioned, that the first cupola was on a totally different principle, and was good; whereas, the present cupola was of a different form, and a different thing altogether. Now, it so happens that the name cupola was never adopted by me, as you will see in my first lecture and pamphlet.

Commander SCOTT: I did not say the cupola. I said the plan of placing cupolas throughout the length of the ship was different from that of the two centre cupolas of the "Naughty Child."

Captain COLES: I am talking of the form.

Commander SCOTT: I did not speak of the principle at all.

Captain COLES: I beg your pardon, I thought it was a reflection when you were comparing this, the cone form and the vertical side, or cylindrical form.

Commander SCOTT: I showed it was different from that cupola — entirely different; but I did not speak of it being on a different principle, because they are both on turntables; but there is a modification that makes them very unlike.

Captain COLES: You said one was good, and you led any one to infer that the other was bad.

Commander SCOTT: The principle is one thing; the position in which cupolas are placed is a different thing.

Captain COLES: I was going to explain. The name cupola was never adopted by me. In my first Lecture, "Revolving gun shields," is the term used. From the first I had five forms. That (pointing to a diagram) is the form which I chose and

adopted for breech-loaders. Now, you speak of the erroneous advantages that had been given to this cupola, in consequence of its being open in the rear. You spoke of the concussion as being very vital to the whole thing, and our having been obliged to cut a hole in the top; but I do not know whether you are cognizant of the facts, that after we cut that small hole (14 inches in diameter) in the top, we put a tarpaulin over, and covered it completely in the rear. Captain Powell and Mr. Liddell, besides the gun's crew, got inside, and we fired, and found no uncomfortable effect from the concussion of that breech-loader. And mark this, for my experience in the cupola with a breech-loader, that the concussion is far worse with a breech-loader, from the escape of gas from the breech, than it would be with a muzzle-loader where there is no escape of gas from the breech except the vent-hole, over which is a hole in the top. Then, with regard to the top being open, the top of the cupola is covered, with the exception of these five holes (20 inches diameter), which are represented by these black spots. You spoke merely of a 40-pounder in the "Excellent," as if that was the only gun that had been experimentalized with. You also said that a brace of guns could not be worked; at least I think so.

Commander Scott: I spoke of 110-pounders being also tried in a wooden cupola.

Captain Coles: Now, in that wooden cupola, Captain Hewlett says, and I may observe, that to a certain extent you are speaking as an officer employed by the Admiralty; and I think I may also, in answering your argument, quote the official letter of Captain Hewlett.

Commander Scott: I do not speak as an officer employed by the Admiralty.

Captain Coles: Captain Hewlett reported the experiment of two 110-pounders in a shield of only 20 external feet diameter as a perfect success. And what we did was this: We not only covered the whole of the top over with a tarpaulin, and put boards on it; but the side of the cupola, which, mind you, would be open between decks, was also covered, and no inconvenience was found by the concussion of the 110-pounders when fired together. And I appeal to all practical gunners whether the concussion from the 110-pounders is not very much more severe than that from the 68-pounder, or any muzzle-loading gun that we know, to the gunners while working it. With regard to smoke, we found not the slightest inconvenience; and I can only refer to the report of Captain Hewlett, who reported that cupola as a complete success, even with the tarpaulin over it. I see in my note, Captain Scott says, "I do not think two guns can be worked side by side." Now, if you can work two 110-pounders in a small shield, why should you not work two 300-pounders in a proportionately larger one? The concussion of a gun, or the recoil of a gun, depends upon the weight of the gun, in proportion to the charge of powder and the shot; and I think we know that the Horsfall gun and the Whitworth heavy gun recoiled very much less than the common 68-pounder, and I know very much less than the 110-pounders, which were employed in my shield. I think I ought to explain to you how I work those guns in the shield. This model represents a cylindrical shield, which I prefer to the cone for *a muzzle-loader*, for the reason, that it gives more room to load the gun. That was my first idea; but in working it out, I found that the construction of this is much more simple, showing so much less area and surface to be covered, making a saving in weight, and simplicity of construction. The spherical shield, I believe, to be equally strong, if not stronger than the conical one. But by way of showing you how these guns work, and the recoil, I will here put in a 110-pounder. Now, all you require is sufficient room for loading; and whether it be between deck or in a cupola, as long as you have sufficient recoil for your gun, I do not see what difficulty there can be in loading. This gun, you will see, when run in, has 3 feet between the muzzle and the side of the shield; and I will appeal to any gunner whether 3 feet between the ship's side, or the shield's side and the muzzle of a gun, is not sufficient to load it. This is not my opinion only. I am not working out the running in and out of these guns on only my own judgment, but have asked, not officially, Captain Hewlett and other gunnery officers of the "Excellent," what distance they consider necessary. They say they consider that it is necessary in working a broadside gun, a 68-pounder, to have 2 feet, and I have 3, which is more than sufficient room to load my 300-pounder muzzle-loader, in the ordinary way, with sponge and rammer. Lifting the shot is done by mechanical appliances, which I will not enter into, beyond

saying, that the man has no trouble except in ramming it home. If I am asked to build a shield, I say let me know the length of the gun and the recoil, and my shield is made accordingly. I make it of such diameter, so that when the gun is in, there shall be from 2 to 3 feet clear of the muzzle of the gun when in. The recoil, you said, was 17½ feet, and my cupola is 19 feet inside; therefore I think I have ample room.

The next question was relative to the effect of the concussion on the deck. In the "Trusty" we fired certainly with only the 40-pounder, but we fired nearly fore and aft. That was merely a wooden deck, secured by spike nails, as all those decks are, and it did not do the slightest injury to that deck, much to my surprise, for I felt that might be one of my great difficulties. The other day, Admiral Elliot, in going over the "Royal Sovereign," said, "There is no fear about that, as long as you have no obstruction the gun will have no effect upon your deck." But, remember, that the deck of the "Royal Sovereign" is 4-inch iron rivetted down to iron beams, and over that is 4 or 5 inches of wood; and that wood is not nailed down as in the ordinary way, but with screw nuts, with large heads to them, that go through the iron plate; so that for that deck to come up, the whole of these screw nuts must break off. I do not think there will be the slightest difficulty with regard to the deck, from what I saw in the "Trusty;" if there is, we must do away with the wood above, put it underneath the iron; but I do not anticipate, from what I saw in the "Trusty," the slightest difficulty.

Another thing which Captain Scott said, as a gunnery officer, which I must make some remark upon was "never ready for action." He said "never ready for action because of the bulwarks." But does Captain Scott know how the bulwarks are fitted. Those bulwarks, supposing that you are taken so much by suprise and your guns were actually loaded at the time, might be blown away if you like. But, on the other hand, those bulwarks are so fitted with a large hinge that by merely withdrawing a pin or button they are released and fall down over the side; it is done instantaneously. We tried it on board the "Royal Sovereign" the other day, and I myself let six feet down. You do not ease it down or anything of that kind; it is made of iron and it falls down when released without the slightest trouble. I believe 2 or 3 men, while you are casting your guns loose, would have the whole of your bulwarks down—if you look at this side of the ship when the bulwarks are down you will see there is nothing in the way. Instead of never being ready for action one of the great points is that this shield ship is always ready for action because the shields are sacred and always clear; as I explained yesterday, nobody goes into the shields excepting to clean and fight his gun, and everything is kept clear of the shield below. One of the things I insist upon is that nothing shall come within 2 feet 6 inches of the shield between decks, the cabins, or cables or anything, so that directly you beat to quarters all your men have to do, is to go into the shields and man the winch-handles and you can commence your work at once. We all know that in these present iron-clad ships the men live between the guns. Before you can fire your gun you must lash your hammocks up, you must remove your mess-tables and stools. I ask, if this is the case—and I appeal to all practical seamen gunners—if this is the case, and I am right, how is it that the shields ship is "never ready for action?" I maintain that it is one of her great points, her always being ready for action and that you can fight her guns with one-half her crew, whereas as I said yesterday you cannot fight in these ships all your broadside guns even with the crews they now have, you can only fight every alternate gun. That is answered by the gunnery drill, of the "Excellent," the rule, at this present moment being that after three rounds you secure one-half your guns and fight the rest.

Another thing Captain Scott said is, these ships are liable to be boarded and that when boarded, or when you wanted to board, you had to cease firing. I think I shall show you that it is exactly the reverse (exhibiting model). I explained yesterday that in this place (platforms in tripod masts see fig. 4). I should have a certain number of small arm men or rifle-men who would enfilade the deck. In the shield ship you will see the same number of hatchways that you have in ordinary ships, therefore my men can come up to board, or repel boarders, just as effectively as they can in any other ship. But suppose I am going to board, having this advantage of working the guns by mechanical appliances and steam which I shall hereafter refer to,

I can be working my guns while half my men are preparing to board. They come up the hatchways and place themselves on the off-side of these shields and lay down behind them. Take for instance a shield 23 feet in diameter; behind which I suppose you can put perhaps 50 men, and they are perfectly protected, lying down upon the deck, whereas, upon the upper deck of any of these vessels your men are *not in the slightest* way protected. I will go on firing with my guns until the last moment. If repelling boarders, I extreme train my foremost guns aft and my after guns forward, enfilading the whole of the deck until the moment that the boarders jump on my deck when a discharge from these guns will blow them all overboard; and having discomfited the enemy, my men are ready to jump from behind the shields and to assault those men who may be left and drive them off the deck. I do not think when you are boarding a ship, as you have been describing as a gunnery officer, you would allow your main deck guns to be playing away with your men jumping over, because if those guns went off you would be blowing your men into the air. I should sound "cease firing" with a tap of the drum, and give the order to board at the same moment which I believe is the general drill on board ship.

I next come to where Captain Scott talked of no large guns being durable. That is a point I am not able to decide upon, but my humble opinion is when the attention of the country is called to great guns, we shall soon have them to perfection. And I think I am borne out in that by an officer whose opinion is worthy of great notice, and that is Captain Fishbourne. If I understand rightly, he is of opinion that great guns will be made, and it is upon that assumption to a great extent, that I ground my arguments. I also ground them upon what they are doing in America. In America they are using these guns, and they find no inconvenience from the concussion in the shields. They are using 24-ton guns and 15-ton guns in these very shields, and they find no inconvenience. Here is an extract of a letter which a gentleman kindly gave me; it is, I believe, on undoubted authority. He says "The number of 15-inch guns already cast and mounted, is 34. The foundry at Pittsburgh is turning out three a week, the foundry at Providence one a week, and the foundry at Boston two a week, making an actual production of one 15-inch gun a day. These guns fire a solid round shot of 450 pounds weight, and a shell of 370 pounds weight, containing 7 lbs. of powder. The charge of powder in the guns is from 40 lbs. to 50 lbs., and you can easily imagine the effect to be terrific." The writer went on to say they were putting those guns into iron-turreted vessels, therefore I think if the Americans, as they have done in many cases lead the way, we must follow them. They have shown us the way in many instances to build ships, and we must not despise their guns—they may be cast-iron guns, and I have no doubt we shall beat them in the long run; but they have taken the initiative in getting these big guns afloat, when we have not a single big gun afloat at all. If I had time now, I would give a great deal tc go over to America to see how they work them in their turrets, because I am certain if they do work them we shall soon be able to follow their example.

About the great effect of the concussion in the shield, really, from what I saw in the very small shield—it was only a shield of 16 feet—it was the first one I made, and I misjudged the size of it, it was too small, and when the gun was fired the men were obliged to crouch back with their heads against the side, and it was just as much as they could do to clear the recoil of the gun, and yet they found no inconvenience. We fired 106 rounds from the cupola, and I was remarkably surprised at the little inconvenience felt.

A MEMBER: I merely go from what I experienced myself. The lower-deck guns firing in action, the concussion of those guns is so great, that I have known many people lose their hearing for many days. I know an officer at the present moment who has lost his hearing for many years by the concussion of the gun in a frigate, at the battle of Algiers—Admiral Jones.

Captain COLES: I quite agree with you. I can say the same thing of Sebastopol. I was deaf for three days; and also that in the "Trusty" we had one gun mounted on the main deck, with the port-hole somewhat open as you see described there and the other guns mounted in the cupola, where I should say there was no port hole at all, for the gun filled it up, and the concussion from the muzzle could not get inside the shield. It was less than it was at the broadside gun, for the concussion

came in from the muzzle through the open port, but there being no port open we do not get the concussion inside the shield, and it was remarkable that, standing upon the deck of the "Trusty," on one side of the shield, people who were standing well in the rear felt the concussion more than you did inside the shield. If I had not seen it myself I should have perfectly agreed with you from what my prior experience had been, that the concussion would have been very bad, and it was one of the great doubts I had about the shield succeeding. The report of Captain Powell, although that officer was appointed to try this shield, has never been whispered to me, and that report has never been published, I have never been allowed to see it, but I think that that report, when it becomes an open question, and there is an *open duel between the two systems, ought to be published*, because I am standing alone, as I may say, Captain Powell cannot open his mouth, and none of the officers who have tried my shield can open their mouths.

I think the next remark was the effect of one shot upon the tripod masts. Now, that is a mere matter of opinion, but I can only here again refer to what I have seen, and I remember that at Sebastopol, in the case of the "Retribution," one shot went through the mainmast, and down it came by the run; the rigging helped to pull it down. But, as I explain, these tubes support the mast (see fig. 5), they do not drag it down as your rigging would do. Your rigging, we know, if set up too tight, would belly your mast and cripple it; but these are always supporting it; and supposing one to be shot away, you have still two tubes mutually supporting each other. Supposing two are shot away, you still have one tube supporting itself, and supposing the third tube to be shot away, then your mast goes overboard, and there is an end of it. It sinks, and does not foul the screw. I do not suppose my mast is never to be shot away; on the contrary, I think if we ever have any hard-fought actions the whole of our masts will go, and the sooner they go the better; the thing is, when they do go, to get rid of them and get them clear of the screw, and that is one of my great objects in having these tripod masts, which, perhaps, to a sailor's eye, at first are unsightly. Again comes the question about shooting them away. We know at Portsmouth they fired at a funnel, I am afraid to say how long, and they could not shoot it away. Remember these masts are 26 inches in diameter, and the shot to carry the whole mast away must be 26 inches in diameter also. But we found in the funnel you hit it here and there; but unless your shot hit it in a row, as a crack shot will cut out a circle in a board with a pistol ball, you will not carry your mast away. If the shot hit here and there you only weaken it, your shot must hit continuously right across the mast to carry it away. We have never heard all through the American war of a single funnel being shot away. At Sebastopol there was no funnel shot away, and I believe, from the very fact of the shot passing clean through them, these masts will be very difficult to be shot away, and I have the opinions of some of our first officers of the navy concurring with me. The next thing was the fouling of the bottom, and I was told I defended the iron bottoms to ships. I must say when you come to carry the heavy armour upon a ship, and from what I know of these gigantic screw vessels, and from what I hear of the officers who, in conversation tell you that they are obliged in these heavy wooden frigates, to put a tarpaulin over their beds below, that they leak so when ever they are under any pressure of steam, from the working of the ship. I do not think these wooden-bottom ships will ever hold together for any length of time with powerful engines and armour plating. It is a serious defect—the fouling of the bottom—and we ought fairly to look it in the face. We have the "Alabama;" that showed us the value of a wooden ship with a copper bottom. A great portion of her success is owing to that. It is a question, however, I won't dwell on; I am fighting only for my shield ships; but still, as it has been broached, I must say this;—I believe, as I said yesterday, that now the attention of the country has been called to it by that discussion in the House the other night, I believe our engineers, ship-builders, and chemists are certain to overcome that difficulty. I myself can see that there are various ways in which it can be done, and you may depend upon it it will be done, because there has been no practical engineering question in this country yet, that the skill of this country has not overcome, and it is upon that broad principle that I assert that in a year that difficulty will be overcome.

I understood Captain Blakeley to bear me out in 20-ton guns being worked in a

shield with ease, and I shall have very much pleasure in putting one of his guns into one of my shields if I can. All I pray for is, a good big gun, and that the gun shall *be heavy in proportion to its charge and its shot*—not a light thing to kick about, as we hear of some jumping off their carriages.

The next shot I think I was favoured with was from Captain Symonds, and with regard to the cupolas he said I had mentioned that other vessels could not bring their guns to bear under some circumstances. Now I think that is a mistake. What I said was this, that there were certain parts or certain points in a ship, where, if the adversary got, the ship must either turn and go off her course, or that ship would remain with impunity to enfilade her; and you must either shift your guns, as you would upon this principal (see Plate xii), to the bow which takes time, or you must turn your vessel. Remember, when you turn your vessel to point your guns, you point 4 guns; if all those guns be pointed exactly in the same direction, and you give the word "fire," you would make very imperfect practice. No gunner will ever tell you you can point your guns to any nicety by the mere working of the helm. With regard to the shield system, the double screw and rapid turning combined; whether that is the best mode of turning your vessel or not; I believe from what I have heard of the experiments, it is one of the best, and it is the very thing above all others that would bring my shield principal out strongest, and in this way, that I can turn my shield quicker than Captain Symonds can turn his vessel. And if my shield were put into Captain Symonds' vessels I can pirouette about, at the same time I can always keep my gun upon the object, whereas, if you have a gun in a port you lose your object perpetually. In calculating the power of turning my shield, I judge it in this way, that the shield will turn quicker than the vessel, so that I can manœuvre with, or I can run through a fleet, or in and out of a place, and I can put my helm whichever way I like and steer my vessel clear of shoals or whatever it may be, without regarding my gunners at all, they take care of themselves, knowing that they can always keep the gun bearing on the object, therefore, the quicker my vessel turns the greater the advantage for me. Another question was that the shield might get locked. Supposing the cupola does get locked, I am not much worse off than any broadside ship; I have got my gun on my broadside, and with Captain Symonds' two screws, if my cupola is locked, I still can point my gun by my helm. I do not look upon the shield being locked as any very serious damage; but I think I shall be able to show you it is almost impossible to lock the shields. This shield weighed 40 tons (the one in the "Trusty"), and the first object of Captain Powell and his gunners, and they were excessively hard hearted, was as they said "we shall stop its working," and what was glory to them was death to me. Whenever a good shot hit it, they said "Oh! it is locked now." After every shot they went on board, and I dare say you can imagine my anxiety to see when they took hold of the winches how it worked. They hit it 44 times with 110 and 68 pounders at 200 yards, and after this severe test (during which the muzzle of the gun was broken off, so we put another gun in it and we fired 6 rounds at targets) it worked, as the men said they thought "*if anything a little better.*" I will ask you, gentlemen, in action how many magazines you would empty before you hit one of these shields 44 times. I believe you would hardly ever hit them. We fired at it 69 times and only hit it 44 times, so I have no fear of its being locked. People who do not know the construction suppose that it is easy to lock it; but remember that there is 3 inches clearance all round it, and if that is not enough I can leave 6 inches clearance. The shield does not touch the deck; the cupola rests entirely upon its base, upon an enormously strong pivot and turn table.

Another question was; it was supposed there might be some difficulty in working the cupola and danger of its jambing in a sea-way. I think that if these 110-pounder shot did not move the cupola weighing only 40 tons, I do not see why cupolas weighing 120 tons, should be moved by heavier shot; and it is only a matter of strengthening the pivot. The pivots are cylinders 2 feet in diameter, of wrought iron, hollow, and 4 inches thick; and I think any engineer can tell you that that cylinder can be made so strong, that if the ship went upon her beam ends, it would take the weight of the 120 or 140 tons with the greatest ease. It is fitted with bearings, &c., like the screw shaft of the engine, or like the shaft of a paddle-wheel. The "Great Eastern's" wheels, I believe, weigh 90 tons, and they are vertical, and we hear nothing about their not

working. The shield is truly balanced, and why should it not work? People seem to think we know nothing about their working, but I maintain we do. We heard of the "Monitor" and those wretched vessels—mind you I call them wretched vessels, because they are nothing but flat bottom rafts—we heard of a vessel going down—we have heard of these vessels off Cape Hatteras in a heavy sea, and we had most graphic descriptions of them in gales of wind, but we never heard of the cupola getting out of its place, you have never heard that; and therefore if those shields have not got out of working order, why should these do it? And allow me to tell you, that Mr. Ericcson's cupolas are very much heavier than mine, because, instead of his having 4 feet above the deck, he has 9 feet to protect with iron, and his shields weigh somewhere about 200 tons. Perhaps my mode of moving it, my mode of pivoting it, and my turn-table, may be all wrong. I do not for a moment say it is right. But it is not my plan; I have taken it from the engineers of this country—I have taken it from the common railway turntable; and I appeal to the engineers of this country, and the Government men who have assisted me, whether they would make a mass of 110 tons to move, and whether the pivot be vertical or horizontal, whether that would not be perfectly secure. Well, gentlemen, with regard to the raking masts, I think it might be an improvement to rake them a little more; the only thing is, that I lose perhaps a little spread of sail in so doing. No doubt the truer you get your tripod the better. I have tried to answer all these questions as shortly as I could, gentlemen, but if I have omitted to answer any, perhaps you will remind me of them, because it is difficult to remember the numerous points I have had to answer. Allow me to thank you for the kind and friendly broadsides which I have received; and I hope if my powder has warmed in the action, that at all events we may have come to some little conclusions with regard to our different arguments. That is the point which gives great assistance and help, and I feel, that in hearing other men's opinions, one finds out one's errors. I have to thank you, gentlemen, for your patient listening, and I shall be happy to explain any thing more I possibly can.

The CHAIRMAN: Gentlemen, this discussion seems now to have closed and I rise therefore merely to do again to-day what I had great pleasure in doing yesterday, to propose that you thank Captain Coles for the instruction you have derived from his lecture. We had this morning in the Institution of Naval Architects the pleasure and the advantage of hearing several papers of very great ability directed very much against this cupola system. To morrow we shall have the pleasure of hearing Captain Coles who will say all he can in favour of the cupola system, and I think that we must all feel that it is by bringing the abilities of competent and scientific men to bear upon questions of this kind that we shall at last elicit the truth. We cannot devote too much pains or too much care to the discussion of a subject bearing so strongly as this does upon the national interests, and whatever may be the ultimate decision with regard to the comparative merits of the cupola system and the broadside system, I repeat now what I said yesterday, that we are under a debt of gratitude to those officers and those men who are devoting their ability and time to the consideration of subjects of so much national importance. I propose to thank Captain Coles for the great ability and care which has distinguished the whole of his lecture and I think I may in justice add, the perfect good temper and good feeling with which he has met all the objections which have been urged against him.

Captain COLES: Allow me again to thank you for the kind manner in which you have received my endeavours. There was one thing I forgot to mention which I think I ought to allude to, which is with regard to the working the guns—the great facility of working the guns in the shield by means of steam. Mr. Cunningham I believe is at present maturing a method for doing that, and with his ability as a scientific man I have no doubt we shall succeed. I have not given my attention to that yet, but I have no doubt we shall be able to work our guns by steam much more easily in the cupola than on the broadside.

working. The shield is truly balanced, and why should it not work? People seem to think we know nothing about their working, but I maintain we do. We heard of the "Monitor" and those wretched vessels—mind you I call them wretched vessels, because they are nothing but flat bottom rafts—we heard of a vessel going down—we have heard of these vessels off Cape Hatteras in a heavy sea, and we had most graphic descriptions of them in gales of wind, but we never heard of the cupola getting out of its place, you have never heard that; and therefore if those shields have not got out of working order, why should these do it? And allow me to tell you, that Mr. Ericcson's cupolas are very much heavier than mine, because, instead of his having 4 feet above the deck, he has 9 feet to protect with iron, and his shields weigh somewhere about 200 tons. Perhaps my mode of moving it, my mode of pivoting it, and my turn-table, may be all wrong. I do not for a moment say it is right. But it is not my plan; I have taken it from the engineers of this country—I have taken it from the common railway turntable; and I appeal to the engineers of this country, and the Government men who have assisted me, whether they would make a mass of 110 tons to move, and whether the pivot be vertical or horizontal, whether that would not be perfectly secure. Well, gentlemen, with regard to the raking masts, I think it might be an improvement to rake them a little more; the only thing is, that I lose perhaps a little spread of sail in so doing. No doubt the truer you get your tripod the better. I have tried to answer all these questions as shortly as I could, gentlemen, but if I have omitted to answer any, perhaps you will remind me of them, because it is difficult to remember the numerous points I have had to answer. Allow me to thank you for the kind and friendly broadsides which I have received; and I hope if my powder has warmed in the action, that at all events we may have come to some little conclusions with regard to our different arguments. That is the point which gives great assistance and help, and I feel, that in hearing other men's opinions, one finds out one's errors. I have to thank you, gentlemen, for your patient listening, and I shall be happy to explain any thing more I possibly can.

The CHAIRMAN: Gentlemen, this discussion seems now to have closed and I rise therefore merely to do again to-day what I had great pleasure in doing yesterday, to propose that you thank Captain Coles for the instruction you have derived from his lecture. We had this morning in the Institution of Naval Architects the pleasure and the advantage of hearing several papers of very great ability directed very much against this cupola system. To morrow we shall have the pleasure of hearing Captain Coles who will say all he can in favour of the cupola system, and I think that we must all feel that it is by bringing the abilities of competent and scientific men to bear upon questions of this kind that we shall at last elicit the truth. We cannot devote too much pains or too much care to the discussion of a subject bearing so strongly as this does upon the national interests, and whatever may be the ultimate decision with regard to the comparative merits of the cupola system and the broadside system, I repeat now what I said yesterday, that we are under a debt of gratitude to those officers and those men who are devoting their ability and time to the consideration of subjects of so much national importance. I propose to thank Captain Coles for the great ability and care which has distinguished the whole of his lecture and I think I may in justice add, the perfect good temper and good feeling with which he has met all the objections which have been urged against him.

Captain COLES: Allow me again to thank you for the kind manner in which you have received my endeavours. There was one thing I forgot to mention which I think I ought to allude to, which is with regard to the working the guns—the great facility of working the guns in the shield by means of steam. Mr. Cunningham I believe is at present maturing a method for doing that, and with his ability as a scientific man I have no doubt we shall succeed. I have not given my attention to that yet, but I have no doubt we shall be able to work our guns by steam much more easily in the cupola than on the broadside.